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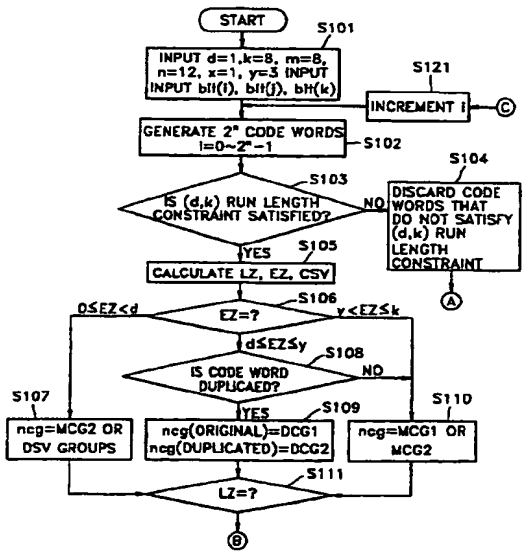
(54) RLL modulation with enhanced DC suppression

(57) An allocating method of allocating a run length limited (RLL) code having enhanced direct current (DC) suppression capability, modulation and demodulation methods, and a demodulation apparatus are provided. In order to control DC suppression, a pair of code groups having suppression controlling capability are allocated, and a (1, 8, 8, 12) code having DC suppression capability, in which

a code word of the pair of code groups has the sign of code word sum value (CSV) parameter, which represent DC value in a code word, and the characteristic of an INV parameter, which predicts the transition direction of digital sum value (DSV) of the succeeding code word, both opposite to those of the code word which belongs to the other code group and corresponds to the same source code, is used and is appropriate to high-density optical disc system.

FIG. 5A



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Description

[0001] The present invention relates to modulation of m-bit information word into a signal and demodulation of the modulated signal, and more particularly, to a method of generating and allocating a (1, 8, 8, 12) code having effective DC suppression in a code word stream, a modulation and demodulation method, a demodulation apparatus therefor, in a run length limited (RLL) code to be used in optical disc recording and/or reproducing apparatuses which require particularly high density recording and/or reproducing.

[0002] In optical recording and/or reproducing apparatuses, a run length limited (RLL) code represented by (d, k, m, n) is widely used for modulating original information into a signal appropriate for an optical disc and demodulating the signal reproduced from the optical disc into the original information. Types of optical discs currently in use include a compact disc (CD), and a digital versatile disc (DVD), and, at present, a high density disc (HD-DVD) which will have a high density recording than that of the DVD is under development.

[0003] Among RLL codes which can be used in the HD-DVD, the characteristic of a (1, 7, 2, 3) code is the fact that its run length is restricted since the minimum run length is 2T(d =1) , and the maximum run length is 8T(k =7) . Its code rate R is R = m/n = 2/3 . T is an interval between each bit in a code word.

[0004] As shown in Figure 1A, 2 bits of data are converted into 3 channel bits. When the run length is violated , that is, when user data "00" is followed by user data "00" or "01", or when user data "10" is followed by user data "00" or "01", the channel bits are replaced by using the conversion table of Figure 1B.

[0005] Since a code word by itself cannot suppress the DC component of the code word in the conventional (1, 7, 2, 3) code, the variation of the Digital Sum Value (DSV) does not converge with DC value "0", as shown in Figure 2 which illustrates the DSV variation curve of the (1, 7, 2, 3) code, when synchronization signals are not added. When this code is used in an optical disc system, a data slicer (also referred to as a data digitizing circuit) which converts a radio frequency signal picked up from the disc into a binary signal cannot properly operate. In addition, the lower frequency component of the code signal flows in a servo unit, which includes a tracking control unit and a focusing control unit, to give a bad influence, and lowers the reliability of the system.

[0006] With a view to solve or reduce the above problems it is an aim of preferred embodiments of the present invention to provide a method of allocating an RLL code which is appropriate for a high-density disc system and is capable of effectual DC suppression in a code word stream.

[0007] It is another aim of embodiments of the present invention to provide a modulation method of modulating an RLL code which is capable of effectively suppressing DC in a code word stream.

[0008] It is still another aim of embodiments of the present invention to provide a modulation method using a code conversion table for DSV control at DSV control points, and otherwise using the main code conversion table.

[0009] It is still further another aim of embodiments of the present invention to provide a modulation method in which the number of code word bits is reduced by using some or all of the code words, already used in the main conversion table as code words of the code conversion table for DSV control for DC suppression.

[0010] It is still yet further another aim of embodiments of the present invention to provide a modulation method capable of effectively suppressing DC by using a sub conversion table for DSV control, which is separate from the main conversion table, the sub conversion table using to the maximum the sign of code word sum value (CSV), which indicates the DC value within a code word, and the characteristic of an INV parameter, which predicts the transition of the DSV in the next code word.

[0011] It is still yet further another aim of embodiments of the present invention to provide a demodulation method capable of effectively suppressing DC in code word streams.

[0012] It is still yet further another aim of embodiments of the present invention to provide a demodulation method of demodulating code words of the conversion table for DSV control for DC suppression, which are modulated using some or all of the code words already used in the main conversion table.

[0013] It is still yet further another aim of embodiments of the present invention to provide a demodulation method of demodulating code words modulated using the sub conversion table for DSV control, which is separate from the main conversion table, the sub conversion table using to the maximum the characteristics of the code words of the main conversion table, that is the characteristics of code word sum value (CSV) and INV parameter.

[0014] It is still yet further another aim of embodiments of the present invention to provide a demodulation apparatus for demodulating the RLL code appropriate for high density disc system.

[0015] According to an aspect of the present invention there is provided an allocating method for allocating code groups grouped by the characteristics of code words after generating a run length limited (RLL) code which is represented by (d, k, m, n), in which d means the minimum run length, k means the maximum run length, m means the length of data bits, and n means the length of code word bits, the allocating method comprising the steps of allocating a pair of code groups for controlling direct current (DC) suppression in a code word stream; and allocating code words to the pair of code groups, the code words corresponding to the same source code, in order that the corresponding code words of each of the code groups have opposite signs of a 1st parameter, code word sum value (CSV), which repre-

sents the DC value in a code word and opposite characteristics of a 2nd parameter INV which predicts the transition direction of the digital sum value (DSV) of the succeeding code word.

[0016] Preferably, code words in each of the pair of code groups, the code words corresponding to the same source code, are arranged in order that the code words have opposite signs of the 1st parameter and opposite characteristics of the 2nd parameter, and the corresponding code words of each of the code groups are made to select the same code group as a code group which includes the succeeding code word so that the digital sum value (DSV) direction of a code stream goes oppositely each other with respect to the identical source codes in the pair of code groups.

[0017] Preferably, code words in a reference code group in the pair of code groups are arranged so that absolute value of their 1st parameters (CSVs) are in descending order.

[0018] Preferably, code words of the reference code group in the pair of code groups and code words of a code group which can control DC suppression are arranged so that the absolute value of their 1st parameters (CSVs) are in descending order and code words corresponding to the same source codes of the reference code group are arranged in order that the code words have opposite signs of the 1st parameter (CSV) and opposite characteristics of the 2nd parameter (INV).

[0019] According to another aspect of the present invention there is provided An allocating method of allocating code groups grouped by the characteristics of code words after generating run length limited (RLL) code which is represent by (d, k, m, n) wherein d means the minimum run length, k means the maximum run length, m means the length of data bits, and n means the length of code word bits, the allocating method comprising the steps of:

allocating a pair of code groups which can control direct current (DC) suppression in order to control suppression of DC in a code word stream; and

allocating code words in the pair of code groups, the code words corresponding to the same source code, so that the code words have the opposite characteristics of a 2nd parameter INV which predicts the transition direction of the digital sum value (DSV) of the succeeding code word and the code words are made to select the same code group as a code group which includes the succeeding code word so that the DSV direction of a code stream goes oppositely and it is advantageous to use a code stream selection algorithm of a look-ahead method.

[0020] According to another aspect of the present invention there is provided An allocating method of allocating code groups grouped by the characteristics of code words after generating run length limited (RLL) code which is represent by (d, k, m, n) wherein d means the minimum run length, k means the maximum run length, m means the length of data bits, and n means the length of code word bits, the allocating method comprising the steps of:

allocating a main code group defined as a code group which include a code word following a not-duplicated code word, and a decision code group defined as a code group which includes a code word following a duplicated code word;

allocating code words of the main code group so that a code word whose lead zero (LZ) number is less than or equal to a main code group division parameter (x) is allocated to a 1st main code group, and a code word whose LZ number is greater than the main code group division parameter (x) is allocated to a 2nd main code group, and there are no the same code words between in the 1st main code group and the 2nd code group; and

allocating code words of the decision code group so that the decision code group is formed with code words which satisfy that LZ is equal to or less than the difference value of the maximum run length (k) and a code word duplication parameter (y) and the code words are allocated to one of a 1st decision code group and a 2nd decision code group according to the value of predetermined bits in each code word.

[0021] Preferably, code words which satisfy that LZ ≤ 3 and the 9th bit or the 5th bit of a code word are "1" are allocated to the 1st decision code group, and code words which satisfy that LZ ≤ 3 and the 9th bit and the 5th bit of a code word are both "0" are allocated to the 2nd decision code group, and there are no the same code words between in the 1st decision code group and the 2nd decision code group.

[0022] Preferably, wherein when the 11th bit in a code word is referred to as the most significant bit and 0th bit in a code word is referred to as the least significant bit, if the most significant bit is "1" or the upper significant 4 bits are all "0", that is, if a code word satisfies that the LZ of the upper significant 4 bits is 0, 4, or 5, the code word is allocated to the 1st decision code group, and if a code word satisfies that the LZ of the upper significant 4 bits is 1, 2, or 3, the code word is allocated to the 2nd decision code group.

[0023] Preferably, as a separate code group for suppression of DC in a code stream, a DSV code group which comprises code words extracted from one of the main code groups is additionally included.

[0024] Preferably, the DSV code group is formed so that, though a code word which includes the next code is the 1st main code group, code words which are included in the 2nd main code group and have possibility of not violating the (d, k) run length constraint are extracted, and the code words are allocated to have the opposite signs of a 1st parameter code word sum value (CSV) which represents the direct current (DC) value in a code word and the opposite characteristics of a 2nd parameter INV which predicts the transition direction of the digital sum value (DSV) of the succeeding code word with respect to code words which are included in the 1st main code group and correspond to the same source codes, and the DSV code group together with the 1st code group additionally controls DC suppression.

[0025] Preferably, the DSV code group is formed so that, though a code word which includes the next code is the 2nd main code group, code words which are included in the 1st main code group and have possibility of not violating the (d, k) run length constraint are extracted, and the code words are allocated to the code group for DSV control to have the opposite signs of the 1st parameter (CSV) and the characteristics of the 2nd parameter (INV) with respect to code words which are included in the 2nd main code group and correspond to the same source codes, and the DSV code group together with the 2nd main code group additionally control DC suppression.

[0026] Preferably, the DSV code group is formed with code words which satisfy LZ is 1, and code words whose number of end zeros is "0" are made to indicate the 2nd main code group as a code group which includes the succeeding code word, and the code words are allocated to have the opposite signs of the 1st parameter (CSV) and the opposite characteristics of the 2nd parameter (INV) with respect to code words which are included in the 2nd main code group and correspond to the same source codes, and the DSV code group together with the 2nd main code group can control suppression of DC in a code word stream.

[0027] According to another aspect of the present invention there is provided a modulation method for modulating data input to optical disc recording/reproducing apparatuses to a run length limited (RLL) code which are represented by (d, k, m, n) in which d means the minimum run length, k means the maximum run length, m means the length of data bits, and n means the length of code word bits, the modulation method comprising the steps of (a) at a point DSV control, modulating m-bit data input with inserting a code word for DSV control, and otherwise, modulating m-bit data input with selecting a code word of one code group in main code groups, in which code words have duplicated code words and code words of each code group are allocated to have the opposite signs of a 1st parameter code word sum value (CSV) which represents direct current (DC) value in a code word and the opposite characteristics of a 2nd parameter (INV) which predicts the transition direction of digital sum value (DSV) of the succeeding code word, and decision code groups for determining whether a code word is the duplicated code word.

[0028] Preferably, when it is not at a point of DSV control, one or more DSV code group which is formed with some or all code words of one main code group in the main code groups and is for DSV control is used for modulation.

[0029] Preferably, if it is the point of DSV control set by the frequency number of inserting a code word for DSV control, input data is modulated into a code word for DSV control, and otherwise, the input data is modulated into a code word of one code group among the main code groups, the decision code groups, and the DSV code group.

[0030] Preferably, the main code groups include the 1st main code group and the 2nd main code group that are a pair of code groups which can control DC suppression; the decision code groups include the 1st decision code group and the 2nd decision code group; and the DSV code group includes some or all of the code words in one of the 1st main code group and the 2nd code group and allocate the code words so that the code words have the opposite signs of the 1st parameter and the opposite characteristics of the 2nd parameter with respect to corresponding code words which are included in the 2nd main code group or the 1st main code group and correspond to the same source codes, and then DC suppression is performed.

[0031] Preferably, the method further comprises the steps of:

(b) checking the number of end zeros (EZ) of the selected code words; and

(c) if EZ ≤$ d-1, making a 3rd parameter (ncg), which indicates a code group of a code word following a code word of the each code group, to point out the 2nd main code group or the DSV code group; if d ≤ EZ ≤ y (y: code word duplication parameter) and the code word is duplicated, making the 3rd parameter to point out the 1st decision code group or the 2nd decision code group; and if y ≤ EZ ≤ k or d ≤ EZ ≤ y and the code word is not duplicated, making the 3rd parameter to indicate the 1st main code group or the 2nd main code group, wherein unless the maximum run length k is violated, code word selection scope can be widened to enhance DC suppression capability.

[0032] Preferably, for the (1, 8, 8, 12) code, d, k, m, and n are set to 1, 8, 8, 12, respectively, and x that is a division parameter for distinguishing the 1st main code group and the 2nd main code group is set to 1, and y that is a parameter for duplicating a code word is set to 3.

[0033] Preferably, the method further comprises a step:

(d) inserting a synchronization pattern every predetermined cycle; wherein synchronization patterns, which are

used when the 3rd parameter points out the 1st main code group or the 2nd decision code group, and synchronization patterns, which are used when the 3rd parameter points out the 2nd main code group or the 1st decision code group, are allocated to have opposite signs of the 1st parameter and opposite characteristics of the 2nd parameter in order to select a synchronization code word advantageous to DSV control.

[0034] Preferably, the method further comprises a step:

(d) inserting a synchronization pattern every predetermined cycle; wherein synchronization patterns, which are used when the 3rd parameter points out the 1st main code group or the 1st decision code group, and synchronization patterns, which are used when the 3rd parameter points out the 2nd main code group or the 2nd decision code group, are allocated to have opposite signs of the 1st parameter and opposite characteristics of the 2nd parameter in order to select a synchronization code word advantageous to DSV control.

[0035] Preferably, the code group pointed out by the 3rd parameter changes depending on whether at a point of DSV control or not, that is, when the number of end zeros is less than the minimum run length, at a point of DSV control, the code group pointed out by the 3rd parameter is the 1st main code group or the 2nd main code group in order to select a code word advantageous to DSV control, and if it is not at a point of DSV control, the code group pointed out by the 3rd parameter is the 2nd main code group or the DSV code group in order to select a code word advantageous to DSV control.

[0036] Preferably, in the step (a), at a point of DSV control, m-bit input data is modulated by using the sub conversion table for DSV control whose code words are added with bits for DSV control in order to more strongly suppress DC component in a code word stream.

[0037] Preferably, the code words of the sub conversion table for DSV control are made by adding predetermined merge bits to the same code words in the main code groups and the decision code groups.

[0038] Preferably, the code words of the sub conversion table for DSV control points out the same code word groups as the main code groups and the decision code groups.

[0039] Preferably, code words of the sub conversion code table are made by adding a DSV control bit to the code words of the main code groups and the decision code groups as MSB.

[0040] Preferably, the 1st main code group is comprised of code words whose LZ is less than or equal to the main code group division parameter (x) "1", and the 2nd main code group is comprised of code words whose LZ is equal to or greater than 1, and the 1st main code group has no code words identical to any code word of the 2nd main code group and vice versa, and code words whose EZ is equal to or greater than the minimum run length (d) and less than or equal to the code word duplication parameter (y) are duplicated.

[0041] Preferably, among code words whose EZ is equal to or greater than the minimum run length (d) and less than or equal to the code word duplication parameter (y), some code words are exceptionally not duplicated by checking a predetermined code group and bits of a code word in order to control more efficient DC suppression.

[0042] Preferably, the exceptionally-not-duplicated code words do not select the 1st decision code group or the 2nd decision code group, but select the 1st main code group or the 2nd main code group as ncg.

[0043] Preferably, code words whose EZ is $1 \leq EZ \leq 3$ are duplicated, however, code words whose EZ is "1" and the upper significant four bits of a code word is 8 (1000b) or 9 (1001b) are not duplicated, and the 3rd parameter (ncg) is made to point out not the 1st decision code group or the 2nd decision code group, but the 1st main code group or the 2nd main code group in order to perform advantageous DSV control.

[0044] According to another aspect of the present invention there is provided a modulation method of modulating data input to optical disc recording/reproducing apparatuses to a run length limited (RLL) code which are represented by (d, k, m, n) wherein d means the minimum run length, k means the maximum run length, m means the length of data bits, and n means the length of code word bits, the modulation method comprising the steps of:

(a) setting a point of DSV control which indicates whether to repeatedly insert a code word for DSV control in a predetermined number of code words; and

(b) when it is not at a point of DSV control, modulating m-bit input data to an n-bit code word selected from the main conversion table, and at a point of DSV control, modulating m-bit input data to a code word selected from a sub conversion table for DSV control, the table comprised of code words longer than n-bit code words of the main conversion table.

[0045] Preferably, the main conversion table is comprised of main code groups and decision code groups for determining whether a code word is duplicated or not, and the main code groups allocated code words so that a code word in a main code group has the sign of the 1st parameter code word sum value (CSV), which represent DC value in the

code word, and the characteristic of the 2nd parameter INV, which predicts the transition direction of digital sum value (DSV) of the succeeding code word, both the sign and the characteristic opposite to those of corresponding code word in the other main code group.

[0046] Preferably, the main conversion table additionally includes one or more DSV code groups which are comprised of some or entire code words of a main code group among the main code groups.

[0047] Preferably, the sub conversion table for DSV control has four states, each state having code words, which are longer than the n-bit code words of the code groups of the main conversion table and different from the n-bit code words, and each state having two code groups, and the two code groups of each state have code words having a 1st parameter code word sum value (CSV), which represents DC value in a code word, opposite to the 1st parameter of the corresponding code word in the other code group in the same state.

[0048] Preferably, the code words of the two code groups of each state select the same next code group which includes the succeeding code word.

[0049] Preferably, the sub conversion table for DSV control has four states, each state having code words, which are longer than the n-bit code words of the code groups of the main conversion table and different from the n-bit code words, and each state having two code groups, the two code groups of each state have code words having a 2nd parameter (INV), which predicts the transition direction of digital sum value (DSV) of the succeeding code word, opposite to the 2nd parameter of the corresponding code word in the other code group in the same state.

[0050] Preferably, the code words of the two code groups of each state select the same next code group which includes the succeeding code word.

[0051] Preferably, the sub conversion table for DSV control is comprised of 14-bit code words which satisfy that d and k are 1 and 8, respectively.

[0052] According to another aspect of the present invention, there is provided a demodulation method of demodulating a code word stream received in optical disc recording/reproducing apparatuses using a Run Length Limited (RLL) code into original data, wherein at a point of DSV control, m-bit input data is modulated to a code word for DSV control, and when it is not at a point of DSV control, m-bit input data is modulated to a code word in one code group among main code groups and decision code groups, the main code groups having duplicated code words and having code words which have a 1st parameter code word sum value (CSV), which represents DC value in a code word, and the characteristic of a 2nd parameter INV, which predicts transition direction of digital sum value (DSV) of the succeeding code word, both opposite to those of the corresponding code words of the other main code group, and the decision code groups for determining whether a code word is the duplicated code words, the demodulation method having the steps of (a) updating a 3rd parameter, which points out the code group having the current code word to be demodulated, according to the characteristics of the previous code words after inputting a code word stream; and (b) demodulating the code word into the corresponding original m-bit data in the code group pointed out by the updated the 3rd parameter when only one current code word exist in the code group pointed out by the updated the 3rd parameter (ncg).

[0053] Preferably, the method further comprises a step of:

(c) checking predetermined bits of the succeeding code word when two duplicated code words exist in the code group pointed out by the updated 3rd parameter (ncg), and if any one bit in the checked bits is "1", demodulating the first code word in the duplicated code words into the original data, and if all bits are "0", demodulating the second code word in the duplicated code words into the original data.

[0054] Preferably, the method further comprises a step of:

(c) when two duplicated code words exist in the code group pointed out by the updated 3rd parameter (ncg), if the number of lead zeros of the succeeding code word is 0, 4, or 5, demodulating the first code word of the duplicated code words into the original data, and if the number of lead zeros of the succeeding code word is 1, 2, or 3, demodulating the second code word into the original data.

[0055] Preferably, the method further comprises a step of:

(c) restoring synchronization pattern after determining whether an input code word stream is synchronization pattern, and initializing the 3rd parameter (ncg) to one of the code groups.

[0056] Preferably, the method further comprises a step of:

(c) when an input code word stream is a code word modulated during a point of DSV control, removing a DSV control bit and then performing the step (a).

[0057] Preferably, the method further comprises a step of:

(c) when an input code word stream is a code word modulated at a point of DSV control, demodulating the code word by using an additional sub conversion table for DSV control.

[0058] Preferably, the RLL data modulated when it is not at a point of DSV control is modulated by using one or more DSV code groups, each DSV code group being comprised of some code words of the main code group.

[0059] Preferably, the step (a) comprises the sub-steps of:

(a1) determining the number of end zeros (EZ) in the preceding code word;

(a2) if the EZ of the preceding code word is "0", updating the 3rd parameter (ncg) as the 2nd main code group;

(a3) if the EZ of the preceding code word is "1", when it is not at a point of DSV control, updating the 3rd parameter (ncg) as either of the 2nd main code group or the DSV code group that are advantageous to DC control, and at a point of DSV control, updating the 3rd parameter (ncg) as either the 1st main code group or the 2nd main code group;

(a4) if the EZ of the preceding code word is equal to or greater than the minimum run length (d) and less than or equal to the code word duplication parameter (y), determining whether or not two duplicated code words exist in the code group pointed out by the 3rd parameter (ncg) of the preceding code word;

(a5) if two duplicated code words exist in the step (a4), checking predetermined bits of the current code word and updating the 3rd parameter as the 1st decision code group or the 2nd decision code group depending on whether the predetermined bits "1" or "0"; and

(a6) if the EZ of the preceding code word is greater than the duplication parameter and less than or equal to the maximum run length (k), or if the two duplicated code words do not exist in the step (a4), updating the 3rd parameter as either the 1st main code group or the 2nd main code group that are advantageous to DC control.

[0060] Preferably, if d is 1; k is 8; m is 8; n is 12; the division parameter (x) which divide the 1st main code group and the 2nd main code group is 1; the code word duplication parameter (y) is 3; and the predetermined bits are the 9th bit and the 5th bit, when any of the 9th bit and the 5th bit is "1" in the step (a5), the 3rd parameter (ncg) is updated as the 1st decision code group, and when all of the predetermined bits are "0", the 3rd parameter (ncg) is updated as the 2nd decision code group.

[0061] Preferably, if d is 1; k is 8; m is 8; n is 12; the division parameter (x) which divide the 1st main code group and the 2nd main code group is 1; the code word duplication parameter (y) is 3; and the predetermined bits are the upper significant 4 bits of the current code word, in the step (a5), when the most significant bit of the current code word is "1" or the upper significant four bits of the current code word are all "0", the 3rd parameter (ncg) is updated as the 1st decision code group, and otherwise the 3rd parameter (ncg) is updated as the 2nd decision code group.

[0062] According to another aspect of the present invention there is provided A demodulation method of demodulating a code word stream received in optical disc recording/reproducing apparatuses using a run length limited (RLL) code into original data, wherein when it is not at a point of DSV control, m-bit input data is modulated to an n-bit code word selected from a main conversion table, and at a point of DSV control, m-bit input data is modulated to a code word which is selected from a sub conversion table for DSV control, the table being comprised of code words longer than n-bit code words of the main conversion table, the demodulation method comprising the steps of:

(a) determining whether a point of DSV control in a received code word stream or not, the point of DSV control when a code word for DSV control is inserted every predetermined number of code words; and

(b) when the result of the step (a) determines that it is not at a point of DSV control, demodulating an n-bit code word in the received code word stream into original m-bit data by using the 1st demodulation table corresponding to the main conversion table, and when the result of the step (a) determines a point of DSV control, demodulating a code word longer than n-bit into original m-bit data by using the 2nd demodulation table corresponding to the sub conversion table for DSV control.

[0063] According to another aspect of the present invention, there is provided a demodulation apparatus for demodulating an n-bit code word into the original m-bit data in optical disc recording/reproducing apparatuses using a

run length limited (RLL) code represented by (d, k, m, n), in which d means the minimum run length, k means the maximum run length, m means the data bit length, and n means the code word bit length, the demodulation apparatus comprising a shift register for storing the preceding code word, a current code word, and the succeeding code word in a received code word stream; a detector for detecting the value of a 3rd parameter (ncg), which points out the next code group of the preceding code word, according to the number of end zeros (EZ) after checking the number of EZ of the preceding code word; a determining unit for supplying a determination signal for determining whether or not a code word is duplicated, after checking a predetermined bit of the preceding code word; and a demodulation code table for supplying m-bit data corresponding to the current code word in the code group pointed out by the 3rd parameter (ncg) of the preceding code word.

[0064] Preferably, the demodulation code table comprises main code groups and decision code groups for determining whether or not duplicated code words exist, and the main code groups have duplicated code words and have code words which have a 1st parameter code word sum value (CSV), which represents DC value in a code word, and the characteristic of a 2nd parameter INV, which predicts transition direction of digital sum value (DSV) of the succeeding code word, both opposite to those of the corresponding code words of the other main code group, and m-bit data corresponding to the current code word is read from the code group pointed out by the 3rd parameter (ncg) of the preceding code word according to the 3rd parameter (ncg), the duplication code word determination signal, and a DSV control signal which indicates a point of DSV control.

[0065] Preferably, the method further comprises a synchronization detection and protection unit for detecting a synchronization pattern in an output from the shift register and using the detected synchronization pattern when the pattern is normally detected, and otherwise using pseudo synchronization pattern.

[0066] Preferably, counting starts from the synchronization pattern detection, and at a point of DSV control corresponding to the frequency of inserting code word for DSV control, the most significant bit is removed from the current code word and the code word is demodulated into original data by using the demodulation code table.

[0067] Preferably, counting starts from the synchronization pattern detection, and at a point of DSV control corresponding to the frequency of inserting code word for DSV control, a code word to which a code word for DSV control is inserted is demodulated by using a separate demodulation code table for DSV control.

[0068] Preferably, the detector comprises:

a 1st bit checking unit for checking the EZ of the preceding code word and supplying an ncg control signal pointing out the next code group according to the EZ value;

a 2nd bit checking unit for checking a predetermined number of highest bits of the preceding code word in order to detect a code word having an exception condition of duplicated code words, and supplying an exception control signal when the predetermined number is checked; and

an ncg extracting and changing circuit for changing the ncg control signal into a 1st state value when the exception control signal supplied from the 2nd bit checking unit and the ncg control signal supplied from the 1st bit checking unit are 3rd state values, and supplying the ncg control signals from the 1st and the 2nd state values supplied from the 1st bit checking unit, without change, when the 2nd bit checking unit does not supply the exception control signal or the ncg control signal is not a 3rd state value.

[0069] Preferably, the ncg extracting and changing circuit, checking the lower significant four bits of the preceding code word, outputs the 3rd parameter (ncg) in the form of the 2nd state value when the EZ is 0;

in the form of the 3rd state value when the EZ is between 1 and 3; and in the form of the 1st state value when the EZ is equal to or greater than 4.

[0070] Preferably, wherein the demodulation code table reads the original data corresponding to the current code word from one code group among the decision code groups if the 3rd parameter (ncg) supplied from the ncg extracting and changing circuit is the 3rd state value.

[0071] Preferably, the demodulation code table reads the original data corresponding to the current code word from one code group among the main code groups if the 3rd parameter (ncg) supplied from the ncg extracting and changing circuit is the 1st state value.

[0072] Preferably, the demodulation code table additionally has one or more DSV code groups, each DSV code group being comprised of some or entire code words of a code group among the main code groups.

[0073] Preferably, if the 3rd parameter (ncg) supplied from the ncg extracting and changing circuit is the 2nd state value and, at a point of DSV control according to the DSV control signal, the demodulation code table reads the original data corresponding to the current code word from a code group among the main code groups, and if it is not at a point

of DSV control, the demodulation code table reads the original data corresponding to the current code word from a main code group whose code words have the opposite signs of the 1st parameter and the opposite characteristics of the 2nd parameter with respect to the code words of the DSV code group.

[0074] Preferably, the 2nd bit checking unit checks whether the upper significant four bits of the preceding code word is 8 (1000b) or 9 (1001b); the determining unit checks whether the 9th bit and the 5th bit of the succeeding code word is "0" or "1"; and the demodulation code table selects one of two duplicated code words according to whether the 3rd parameter (ncg) is the 3rd state value and any of the 9th bit and the 5th bit is "1".

[0075] Preferably, the 2nd bit checking unit checks whether the upper significant four bits of the preceding code word is 8 (1000b) or 9 (1001b); the determining unit checks whether the upper significant four bits of the succeeding code word; and the demodulation code table selects one of two duplicated code words according to whether the 3rd parameter (ncg) is the 3rd state value and what is the number of lead zeros of the upper significant four bits.

[0076] Preferably, the ncg extracting and changing circuit changes the 3rd state value of the ncg control signal supplied from the 1st bit checking unit into the 1st state value in order to make the 3rd parameter (ncg) of a not-duplicated code word point out one code group among main code groups when the EZ of the preceding code word is 1 and the upper significant four bits is 8 (1000b) or 9 (1001b).

[0077] Preferably, d is 1, k is 8, m is 8, n is 12, and the RLL code is (1, 8, 8, 12) code.

[0078] For a better understanding of the invention, and to show how embodiments of the same may be carried into effect, reference will now be made, by way of example, to the accompanying diagrammatic drawings in which:

[0079] The above objectives and advantages of the present invention will become more apparent by describing in detail preferred embodiments thereof with reference to the attached drawings in which:

Figure 1A illustrates a conventional (1, 7, 2, 3) code conversion table, and Figure 1B illustrates a substitution conversion table used when the run length of the (1, 7, 2, 3) code is violated;

Figure 2 is a curve showing the variation of a digital sum value (DSV) of the conventional (1, 7, 2, 3) code;

Figure 3 illustrates a DSV control method using merge bits, in order to help one understand the present invention;

Figure 4 illustrates a DSV control method using a separate DSV code, in order to help one understand the present invention;

Figures 5A and 5B are a flowchart for describing a method of generating code groups for a Run Length Limited (RLL) code in order to help one understand the present invention;

Figures 6A and 6B are tables showing the number of available code words in the (1, 8, 8, 12) code according to the present invention;

Figures 7A through 7E are a main conversion table of the (1, 8, 8, 12) code generated by the method of Figures 5A and 5B;

Figure 8 is a main conversion table for DSV control of the (1, 8, 8, 12) code generated by the method of Figures 5A and 5B;

Figures 9A through 9E are a sub conversion table for DSV control of the (1, 8, 8, 12) code generated by the method of Figures 5A and 5B;

Figure 10 illustrates the power spectrum of the (1, 8, 8, 12) code which uses the sub conversion table for DSV control of Figures 9A through 9E;

Figure 11 illustrates the DSV variation curve of the (1, 8, 8, 12) code which does not use the sub conversion table for DSV control of Figures 9A through 9E;

Figures 12A through 12C are another example of a sub conversion table for DSV control, which is separate from the main conversion table;

Figures 13A through 13C are another example of a sub conversion table for DSV control, in which the code words in the table are allocated in order that CSV signs and INV characteristics are opposite to those of the corresponding code words of Figures 12A through 12C;

Figures 14A and 14B are a flowchart for describing an embodiment of a method of generating code groups for the (1, 8, 8, 12) code using the RLL code group generation method of Figures 5A and 5B;

Figures 15A through 15E are a main conversion table of the (1, 8, 8, 12) code generated by the method of Figures 14A and 14B;

Figure 16 is a main conversion table for DSV control of the (1, 8, 8, 12) code generated by the method of Figures 14A and 14B;

Figures 17A through 17E are a sub conversion table for DSV control of the (1, 8, 8, 12) code generated by the method of Figures 14A and 14B;

Figure 18 illustrates a power spectrum density curve of the (1, 8, 8, 12) code using only the main conversion table of Figures 15A through 16;

Figure 19 illustrates DC suppression effect of the INV parameter in the (1, 8, 8, 12) code by using only the main conversion table of Figures 15A through 16;

Figure 20 illustrates DC suppression effect of the DSV code group in the (1, 8, 8, 12) code by using only the main conversion table of Figures 15A through 16;

Figure 21 illustrates DC suppression effect when merge bits for DSV control are added at the (1, 8, 8, 12) code using the main conversion table and the sub conversion table of Figures 15A through 17E;

Figures 22A and 22B are a flowchart for describing an embodiment of a method of modulating the (1, 8, 8, 12) code;

Figure 23 is an example of a synchronization pattern which can be used in the (1, 8, 8, 12) code according to the present invention which uses the code conversion tables of Figures 7A through 9E;

Figure 24 is another example of a synchronization pattern which can be used in the (1, 8, 8, 12) code according to the present invention which uses the code conversion tables of Figures 15A through 17E;

Figure 25 illustrates code groups indicated by ncg used in the present invention;

Figures 26A and 26B are a flowchart for describing an embodiment of a method of demodulating the (1, 8, 8, 12) code, in which the code modulated by the method of Figures 22A and 22B using the code conversion tables of Figures 7A through 9E is demodulated into the original data;

Figure 27 is a circuit diagram of an embodiment of an apparatus for demodulating the (1, 8, 8, 12) code, according to the present invention, the circuit implemented according to the demodulation method of Figures 26A and 26B;

Figures 28A and 28B are a flowchart of another embodiment of the method of demodulating the (1, 8, 8, 12) code in which the code modulated by the method of Figure 22A and 22B using the code conversion tables of Figures 15A through 17E is demodulated into the original data; and

Figure 29 is a circuit diagram of an embodiment of an apparatus for demodulating the (1, 8, 8, 12) code according to the present invention, the circuit implemented according to the demodulation method of Figures 28A and 28B.

[0080] Hereinafter, embodiments of the present invention will be described in detail with reference to the attached drawings. The present invention is not restricted to the following embodiments, and many variations are possible within the spirit and scope of the present invention. The embodiments of the present invention are provided in order to more completely explain the present invention to anyone skilled in the art.

[0081] Among factors indicating code performance of a run length limited (RLL) code, which is represented by (d, k, m, n), recording density and DC suppression capability are generally used in evaluating the superiority thereof. The recording density and detection window margin of a code are expressed as the following equations 1 and 2.

$$\text{recording density} = (d + 1)\, m/n \tag{1}$$

detection window margin = (m/n)T (2)

[0082] Here, m is the number of data bits (also referred to as the number of source bits, or information word bit number), n is the number of code word bits after modulation (also referred to as channel bit number), d is the minimum number of consecutive zeros which can exist between the "1" bits in a code word, k is the maximum number of consecutive zeros which can exist between the "1" bits in a code word, and T is an interval between each bit in a code word.

[0083] As shown in the equation 1, a way for enhancing recording density in a modulation method is to reduce n, the number of code word bits, while maintaining the same d and m. However, the RLL code must satisfy the constraint that d is the minimum number of consecutive zeros situated between the "1" bits in a code word, and the constraint that k is the maximum number of consecutive zeros situated between the "1" bits in a code word. If the number of data bits that satisfy the (d, k) constraint is m, the number of code words that satisfy the RLL (d, k) constraint must be 2^m or more. However, in order to actually use such codes, even a part which connects a code word to another code word must satisfy the RLL (d, k) constraint, and the code must have DC suppression capability when it is used in optical disc recording and/or reproducing apparatuses in which the DC component of a code affects system performance.

[0084] For this reason, as for a compact disc (CD), an Eight-to-Fourteen Modulation (EFM) code, wherein 8 bits of data is modulated into a 14-bit code word, requires an additional 3 merge bits between code words in addition to the 14-bit converted code word in order to have DC suppression capability and to satisfy a run length constraint of the RLL (2, 10) (CD uses a code of 'd=2' and 'k=10'). The merge bits are added only to obtain a desired run length (d, k) and DC suppression and do not include any information. Thus, they become a heavy burden in enhancing recording density.

[0085] As for a digital versatile disc (DVD), an EFM plus (EFM+) code is used. The EFM+ code also has a run length constraint of the RLL (2, 10), but does not use merge bits. Instead, the length (n) of a code word is 16 bits. If the run length (2, 10) is satisfied by using the four main conversion tables, DC suppression of the code stream is carried out by using the sub conversion table.

[0086] The above described code is superior in the aspect of suppression of the DC component. In particular, the EFM+ code which is applied to a DVD reduces the number of code word bits by one bit, and achieves a 5.9% increase in recording density by only changing a code modulation method, compared to the EFM code which is applied to a CD. However, the EFM+ code also requires four additional sub conversion tables, which causes a problem in that it is difficult to reduce the number of code word bits.

[0087] The major reason for suppressing the DC component in the RLL modulated code is to minimize the influence of a reproduced signal on the servo bandwidth. The method of suppressing the DC component will be referred to as a digital sum value (DSV) control method hereinafter.

[0088] The DSV control method can be broadly divided into two types. One method includes DSV control codes in the code itself for controlling the DSV, while the other method inserts merge bits at DSV control points. Among the codes described above, the EFM+ code performs DSV control by using a separate code table, while an EFM code or (1, 7) code performs DSV control by inserting merge bits.

[0089] According to the DSV control method which uses merge bits as shown in Figure 3, at a point which is not a DSV control point, an m-bit source code is converted into an n-bit channel code, and at a DSV control point, p merge bits are inserted. At this time, DSV control can only be performed when the (d, k) constraint of the RLL code is satisfied. When the (d, k) constraint is satisfied in the p merge bits, DSV control is performed in order that the cumulative DSV becomes smaller. At this time, if it is considered that DSV control is performed once every N codes, the actual number of channel bits corresponding to N source codes is $N*n+p$.

[0090] When DSV control is performed by adding merge bits, DSV control cannot be performed at every DSV point. DSV control can only be performed when the (d, k) constraint of the RLL code is satisfied during merging. As an example, when 1 and 2 merge bits are inserted respectively in an RLL code which satisfies a (1, 8) constraint, the probability that DSV control is performed during each merge is 75% and 95%, respectively. Based on this fact, DSV control can be performed at every DSV point, as shown in Figure 4, by using a separate modulation code table for DSV.

[0091] That is, instead of inserting merge bits at a DSV control point, a channel code of the DSV control point is obtained from a separate code table designed for DSV control. The separate code table for DSV control is designed to enable DSV control. In general, a q-bit code word of the separate code table for DSV control satisfies a condition that it is bigger than an n-bit channel word ($q > n$).

[0092] At a point which is not a DSV control point, an m-bit source code is converted into an n-bit channel code, and at a point which is a DSV control point, an m-bit source code is converted into a q-bit channel code. DSV control is performed in order that a code which minimizes the cumulated DSV is selected from q1 and q2, both of which can perform DSV control. The codes q1 and q2 are obtained from a code table which is formed to always enable DSV control, and always enable DSV control at every DSV point. In Figure 4, it it is considered that DSV control is performed once every N codes, the number of channel bits corresponding to N source codes is $(N-1)*n+q$ bits.

[0093] Therefore, according to the present invention, some or all code words which are already used in the main conversion table are used as code words of a sub conversion table for DSV control for suppressing DC, which enables

the number of code word bits to be reduced. By taking full advantage of the characteristics of code words in the main conversion table, that is, a CSV parameter which indicates the DC value in a code word and an INV parameter which predicts the transition direction of the next code word, and, by creating a sub conversion table for DSV control which is separate from the main conversion table, effective DC suppression can be achieved.

[0094] An RLL code generating method which increases DC suppression and recording density by using these main and sub conversion tables and is particularly appropriate for a high-density optical disc system will now be described.

[0095] First, terms used in the present invention will be described.

(Preceding code)		(Current code)	
000010001001000		001000001001000	
LZ(p)	EZ(p)	LZ(c)	EZ(c)

[0096] Here, the minimum run length is d, the maximum run length is k, the length of data bits is m, and the length of code word bits is n. LZ(p) and LZ(c) are the number of lead zeros in a previous code word and in a current code word, respectively, while EZ(p) and EZ(c) are the number of end zeros in a previous code word and in a current code word, respectively. DSV is a digital sum value in a code word stream, that is, a value made by cumulatively adding "0" bits, which are treated as "-1", and "1" bits, which are treated as "+1" in an inverted pattern after inverting "1" or "0" until comes the next "1" in a series of code word streams. CSV is a digital sum value in a code word, that is, a value made by cumulatively adding 0, which are treated as "-1", and 1, which are treated as "+1" in the inverted pattern after inverting "1" or "0" until comes the next "1" in a code word. INV is a parameter which predicts the transition of a next code word. If there is an even number of "1" bits in a code word, the INV parameter is 0 (INV=0), and, if the number of "1" bits in a code word is an odd number, the INV parameter value is 1. (INv=1). 'x' is a parameter which divides the main code groups, 'y' is a duplication parameter, and bit(i), bit(j), and bit(k) represent ith, jth, and kth bits, respectively, in a code word. Here, if the INV cumulated in a code word stream is 0, the DSV is updated by adding the inverted CSV of the next code, without change, to the DSV value cumulated previously, and, if the INV value is "1," the DSV is updated by adding the CSV of the next code to the DSV value cumulated previously after inverting the sign of the CSV of the next code.

[0097] If the above stream are taken as an example, INV, CSV, and DSV parameters are given as follows.

Code word:	000010001001000	001001001001000
INV:	0	
CSV:	+1	-3
code stream:	000011110001111	110001110001111

DSV: -1,-2,-3,-4,-3,-2,-1, 0,-1,-2,-3,-1, 0,+1
+2,+3,+2,+1, 0,+1,+2,+3,+2,+1, 0,+1,+2,+3,+4

[0098] This method was proposed in the Patent Application No. 99-7723 which was filed under the title of "Method of generating Run Length Limited (RLL) code having improved DC suppression capability and modulation/demodulation method of the generated RLL code" in Korea on March 9, 1999, by the above applicants. For reference, the method will now be described referring to Figures 5A and 5B.

[0099] Referring to Figures 5A and 5B which are a flowchart of a method of generating an RLL code group in order to help one understand the present invention, the minimum run length (d), the maximum run length (k), the data bit length (m), the code word bit length (n), the division parameter (x) of the main conversion group, the code word dupli-

cation parameter (y), and predetermined bits (bit (i), bit (j), bit (k)) are input as desired in step S101.

[0100] 2^n code words from 0 through 2^n-1 that satisfy the constraints set in the step S101 are generated in step S102. It is determined whether the generated codes satisfy the (d, k) run length constraint in step S103. Since only those codes that satisfy the (d, k) run length constraint can be used among the generated codes, the code words that do not satisfy the (d, k) run length constraint are discarded in step S104. The characteristics of code words are extracted from the code words that satisfy the run length (d, k) constraint in step S105, and parameters for extracting required characteristics include the number of lead zeros (LZ), the number of end zeros (EZ), and the code word sum value (CSV) of each code word.

[0101] Some code words are duplicated in order to increase the number of available codes, and the EZ values are checked in order to satisfy the (d, k) constraint of connection parts between code words in step 106. According to the EZ values, the following operations are performed.

[0102] If the number of end zeros (EZ) in a code word is $0 \leq EZ < d$, the code words of the next code group (hereinafter referred as ncg) are selected in order that the next code word is selected from the 2nd Main Code Group (MCG2) or the DSV group, in step S107.

[0103] If the EZ value in a code word is $d \leq EZ \leq y$, it is determined whether the cord word is duplicated in step S108. If the cord word is an original code word and not duplicated, the ncg is selected in order that the next code word can be selected from the 1st Decision Code Group (DCG1), and, if the code word is duplicated, the ncg is selected in order that the next code word can be selected from the 2nd Decision Code Group (DCG2) in step S109.

[0104] If the EZ value of a code word checked in the step S106 is $y < EZ \leq k$, or if the EZ value is $d \leq EZ \leq y$ and the code word is not duplicated, the ncg of the code word is selected in order that the next code word can be selected from one of the 1st main code group (MCG1) and the MCG2 in step S110.

[0105] In this manner, the ncg of code words that satisfy the (d, k) constraint is selected. According to the ncg, a code group of next code word that can be attached to the current code word is determined, and the connection part of code words also satisfies the (d, k) constraint. Here, the reason why the codes that satisfy $d \leq EZ \leq y$ are duplicated is that, for the codes of which EZ values are 0, 1, ..., d-1, DSV control of a code word stream is performed by using DSV groups in order to suppress the entire DC component.

[0106] A method of grouping code words by code group and the characteristics of each code group will now be described. In order to group code words by code group, the number of lead zeros, that is, an LZ value, is used, and the LZ value of a code word is checked in step 111.

[0107] If the LZ value of a code word is less than or equal to x, the code word is stored in the MCG1 in step S112. If the LZ value is $LZ > x$, the cord word is stored in the MCG2 in order that a code word, which has the characteristic of INV and the sign of CSV values opposite to those of an MCG1 code word that has the same decoded value, is allocated in step S113. If there is no code word of which both INV and CSV have opposite characteristic and sign, then a code word which has the opposite CSV sign is allocated, and, next a code word which has the opposite INV value is allocated. The reason for allocating code words in this way is to enable the selection of a code word that has better capability for suppressing the DC component if both code words, which have the same decoded value, of the two code groups satisfy the (d, k) constraint when the ncg of a code word commands to call a next code word in the MCG1 or the MCG2. At the same time, it is because the code words which included in the two code groups and correspond to the same data have opposite INV and CSV values, which allows DC control to be performed optimally in one of the two code words.

[0108] If the LZ value is $LZ \leq k - y$, bit(i), bit(j), and bit(k) are checked in step S114.

[0109] If at least one of the bits is "1", the code word is stored in the DCG1 in step S115. If the bits checked in the step S114 are all "0", the code word is stored in the DCG2 in step S116. The allocation of code words in the DCGs is carried out in order that as many code words as possible may have the same positions in the MCG1 and the MCG2. For example, if "100010001000100" is a code word in the MCG1 and included in the DCG1, and the code word has a decoded value of 128 in the MCG1, the code word is allocated in the position, in the DCG1, at which the decoded value corresponds to 128. This is to minimize error propagation when an error occurs in decoding.

[0110] The reason for allocating code words which satisfy $LZ \leq k - y$ to the DCGs is because the code words which satisfy $d \leq EZ \leq y$ are duplicated. When duplicated code words are decoded, the next code word is referred to in order to correctly decode duplicated code words into corresponding data. If the next code word is selected from the DCG1, the code word is demodulated into the decoded data corresponding to the original code word, and if the next code word is selected from the DCG2, the code word is demodulated into the decoded data corresponding to the duplicated code word.

[0111] In addition, in order that the code words that satisfy $d \leq EZ \leq y$ may be connected with code words of the DCG1 or the DCG2 while satisfying the (d, k) constraint, EZ(p) + LZ(c), the sum of the number of end zeros of the preceding code word, EZ(p), and the number of lead zeros of the current code word, LZ(c), must satisfy $d \leq EZ(p) + LZ(c) \leq k$, and therefore LZ(c) of the decision group must satisfy $LZ \leq k - y$.

[0112] For example, upon decoding, when two duplicated "100010001000100" code words exist in the MCG1, that

is, when the decoded value of the original code word "100010001000100" is 128 and the ncg is the DCG1, and the decoded value of the duplicated code word "100010001000100" is 129 and the ncg is the DCG2, the code word "100010001000100" is demodulated into 128 or 129 depending on whether the ncg is the DCG1 or the DCG2. The allocation of DSV groups will now be described. The DSV groups are proposed in the present invention as a method of suppressing the DC component in a code word stream, and correspond to sub-code groups because the DSV groups use code words which are already used in the MCG1 and do not require additional code words.

[0113] In step S117, the code words which satisfy LZ = x are allocated in the 1st DSV code group in order that the code words have the same positions as in the MCG2 and opposite CSV signs and INV characteristics to each other. In step S118, the code words which satisfy LZ = x or x-1 are allocated in the 2nd DSV code group in order that the code words have the same positions as in the MCG2 and opposite CSV signs and INV characteristics. In the same manner, in step S119, the code words which satisfy LZ = x, x-1, ..., or x -1 are allocated in DSV code group 1 +1 in order that the code words have the same positions as in the MCG2 and opposite CSV signs and INV characteristics. The allocation of code words in DSV groups are carried out as in the MCG1. That is, if identical code words are in the MCG1 and a DSV group, the code word of the DSV group is placed at the same position in the DSV group as that of the identical code word in the MCG1, and by doing so, the identical code words in the two code groups can be decoded into the same data.

[0114] As described in the step S107, when the EZ value of a code word satisfies $0 \leq EZ < d$, the ncg is selected from one of the MCG2 group and the DSV groups. Since the code words in the DSV group are extracted from the MCG1 among the main code groups according to the present invention, the code words in the DSV groups are clearly distinguished from the code words in the MCG2 . A code word which follows the code word that satisfies $0 \leq EZ < d$ is selected from one of the MCG2 and the DSV group, which has better capability for suppressing the DC component.

[0115] Therefore, the method of selecting the DSV group is carried out in order that, if $d \leq EZ(p) + LZ(c) \leq k$ is satisfied and EZ(p) is 0, a code word in DSV group 1 is selected, if EZ(p) is 1, a code word in DSV group 2 is selected, and in the same manner, if EZ(p) is x, x-1, ..., or x-1, a code word in DSV group 1+1 is selected.

[0116] Therefore, the ncg (next code group) which points out a code group of code words that follow the code words existing in each code group checks the EZ value of a code word, and, if $EZ \leq d-1$ is satisfied, the ncg is made to indicate the 2nd main code group or the DSV code group. If $d \leq EZ \leq y$ is satisfied and the code word is duplicated, the ncg is made to indicate the 1st decision code group or the 2nd decision code group, and, if $y < EZ \leq k$ is satisfied or $d \leq EZ \leq y$ is satisfied and the code word is not duplicated, the ncg is made to indicate the 1st main code group or the 2nd main code group. By doing so, when the maximum run length k is not violated, the scope of code selection can be widened, which enhances DC suppression capability of a code.

[0117] The selected code word is stored in the corresponding code group. After determining whether or not data is the last data in step S120, if it is the last data, the allocation is finished, and, otherwise, i (here, $i = 0, 1, ..., 2^{n-1}$) is incremented in step S121, and the step S102 in which 2^n code words are generated is carried out.

[0118] Figures 6A and 6B show the number of available code words in the (1, 8, 8, 12) code proposed by the present invention. The generated code words are divided into 5 code groups based on the characteristics of the code words, and the five code groups are divided into two main code groups (MCG1, MCG2), two decision code groups (DCG1, DCG2), and one DSV code group, based on respective functions of the code groups.

[0119] Here, no identical code words exist in the two main code groups MCG1 and MCG2, and likewise no identical code words exist in the two decision code groups DCG1 and DCG2. Here, the main code group is defined as a code group which is comprised of code words that follow a code word which is not duplicated, and the decision code group is defined as a code group which is comprised of code words that follow a code word which is duplicated. Therefore, the code groups can be differently named later depending on the purpose of code word use, but the meaning of the code groups will be maintained within the above scope.

[0120] The DSV code group is a separate code group for suppressing the DC component in a code stream. 70 code words which belong to the DSV code group all begin with "010" and belong to the 1st main code group (MCG1) which is one of the main code groups. A main code group and a decision code group must each have 256 code words. The 1st main code group (MCG1) lacks 70 code words and the 2nd main code group (MCG2) lacks 58 code words. The total number of lacking code words is 128. The lacking code words are complemented with code words which begin with "01." Therefore, except the DSV code group, if one code word in the 2nd decision code group (DCG2) is excluded, all code groups have 256 code words, respectively.

[0121] The code conversion table generated by the characteristics of the code groups of Figure 6A is shown in Figures 7A through 8, and the code conversion table generated by the characteristics of the code groups of Figure 6B is shown in Figures 15A through 16.

[0122] Figures 7A through 7E are the main conversion table, which is divided into code groups (MCG1, MCG2, DCG1, DCG2), for the (1, 8, 8, 12) code of the present invention, and illustrate an example of a code conversion table when parameters are set as d =1, k =8, m =8, n =12, x =1, y =3, bit(i) =bit(j) =9 , bit (k) =5.

[0123] First, in a main code group, for example, in the 1st main code group (MCG1), 70 code words of 186 code

words which satisfy LZ =0 and no code words among 128 code words which satisfy LZ =1 are allocated. As for what code words will be allocated in the 1st main code group (MCG1), though it is very experimental, one that is advantageous to DSV control among code words corresponding to the same source words in the 1st main code group (MCG1) and the 2nd main code group (MCG2) is selected. Here, code words corresponding to the same source words are allocated in order that they have opposite CSV signs and INV characteristics.

[0124] Once all code groups except the DSV code group obtain 256 code words, first, code words of the MCG1 and the MCG2 are allocated so that the absolute values of their CSVs are in descending order. Then, the code words of the MCG2 are re-allocated in an order in which the MCG2 code words have opposite INV characteristics as well as opposite CSV signs with respect to the corresponding MCG1 code words. Likewise, 70 code words of the DSV code group are allocated so that the absolute values of their CSVs are in descending order, and then, re-allocated in an order in which the DSV code words have opposite INV characteristics as well as opposite CSV signs with respect to the MCG2 code words corresponding to the same source words.

[0125] In the meantime, in addition to the above-described allocation method in which code words are allocated to have opposite INV characteristics and CSV signs, other methods can be implemented as a code word allocation method of allocating a pair of code groups which can control DC suppression (for example, the MCG1 and the MCG2, or the MCG2 and the DSV code group). In one of such methods, code words in a pair of code groups which can control DC suppression, in which the code words correspond to the same source words, have opposite CSV signs and INV characteristics, and select the same code group of the next code words so that the DSV direction of a code word streams goes oppositely each other with respects to the identical source codes in the pair of code groups. Alternatively, the code words which correspond to the same source words can have opposite INVs and select the same code group of the next code words so that the DSV direction of a code word stream can converge on "0" even if the current DSV is disadvantageous, which is particularly advantageous when the code stream selection algorithm of a look-ahead method is used.

[0126] These code group pairs, the MCG1 and the MCG2, or the MCG2 and the DSV code group, are the code groups which can control DC suppression, and DC suppression capability when code words have opposite CSV signs and INV characteristics can be expected to have an additional suppression effect of about 2-3 dB compared to DC suppression capability when code words have only opposite CSV signs.

[0127] Figure 8 shows the main conversion table for DSV control. As described above, in order to make the DSV code group and the main conversion table for DSV control, 70 code words which satisfy LZ =1 and belong to the MCG1 are grouped and allocated in order that the code words have opposite CSV signs and INV characteristics compared to the code words in the MCG2. If a point is not a DSV inserting point when DSV control bits are inserted into a code word to be modulated, DSV control is carried out by selectively using one of the MCG2 conversion table of Figures 7A through 7E and the main conversion table for DSV control of Figure 8 when input data to be modulated is less than 70.

[0128] Here, even though a code group which has the next code word is the MCG1, the DSV code group can be made by using code words which are included in the MCG2 and have possibility of obeying the (d, k) run length constraint. At this time, the code words which have opposite CSV signs and INV characteristics compared to the MCG1 code word corresponding to the same source words are allocated to the DSV control code group. By doing so, additional DC suppression control can be carried out together with the MCG1.

[0129] Figures 9A through 9E are a sub conversion table for DSV control for use instead of the main conversion table of Figures 7A through 7E at a point which is a DSV control point when DSV control bits are inserted into a code word to be modulated. Contrary to Figures 7A through 8, each code word is formed with 13 bits, and the most significant bit (MSB)is a bit for DSV control. 'x' means that both 0 and 1 can be used, and one that is advantageous to DSV control is selected. The characteristic of the sub conversion table for DSV control is that 1 merge bit is added to the number of bits in each code word of the main conversion table of Figures 7A through 7E, and the merge bit is allocated to the MSB, and the value is represented as x which can be selected as "0" or "1" in order not to violate the run length constraint.

[0130] Therefore, the sub conversion table has a characteristic in that x of the MSB is selected in one of "0" and "1", which is advantageous to DSV control, and the other bits except the MSB bit (12 bits in the present embodiment) are the same as those in the main conversion table. However, the code words in Figures 9A through 9E are for DSV control and have the greater number of bits (here, 13 bits) compared to the main conversion code words, and, when the designer more strongly desires to the DSV control, a code word appropriate for DSV control can be found and designed by using 13 bits which are separate from the main conversion table, without using the merge bit. At this time, the code words can be formed with a predetermined number of bits (for example, equal to or more than 13 bits), which are separate from the sub conversion table, for DSV control using the tables of Figures 9A through 9E.

[0131] Figure 10 illustrates the DSV variation curves of the (1, 8, 8, 12) code which uses the code table of Figures 7A through 9E, and shows the result obtained by simulating DC performance of code words according to the DSV control frequency (the frequency of usage of the sub conversion table for DSV control of Figures 9A through 9E). Shown from top to bottom are the power spectrum when the sub conversion table for DSV control is not used; the power spectrum when the sub conversion table for DSV control is used once for every 8 code words; the power spectrum when the

sub conversion table for DSV control is used once for every 4 code words; the power spectrum when the sub conversion table for DSV control is used once for every 2 code words; and the power spectrum when the sub conversion table for DSV control is used once for every code word.

[0132] Input data is random data, and it is shown that the low-frequency component of a code word is decreased as the frequency of usage of the sub conversion table for DSV control of Figures 9A through 9E becomes higher. In addition, as shown in Figure 11, when only the main conversion table (Figures 7A through 7E) and the main conversion table for DSV control (Figure 8) are used without using the sub conversion table for DSV control (Figures 9A through 9E), it is characteristic that the DSV value is continuously converging on "0" contrary to Figure 2 which is the DSV variation curve of the conventional (1, 7, 2, 3) code.

[0133] Figures 12A through 12C and Figures 13A through 13C are sub conversion tables for DSV control which are generated with satisfying the constraints of d =1 and k =8 by using the RLL code generation method of Figures 14A and 14B, and separate from the main conversion table. The sub conversion table for DSV control of Figures 9A through 9E uses the main conversion table code words of Figures 7A through 7E without change and the most significant bit is used as the DSV control bit in a code word, while the sub conversion tables for DSV control of Figures 12A through 12C and 13A through 13C use 14-bit code words separate from the main conversion table.

[0134] The separate sub conversion tables for DSV control of Figures 12A through 12C and 13A through 13C include each four code groups. The code groups (MCG1-1, MCG2-1, DCG1-1, DCG2-1) of the sub conversion table of Figures 12A through 12C and corresponding code groups (MCG1-2, MCG2-2, DCG1-2, DCG2-2) of the sub conversion table of Figures 13A through 13C are allocated as the characteristic of the main conversion table code words in order that the code words have opposite CSV signs and INV characteristics. At the same time, the next code group are identically selected so that the DSV direction of a code stream goes oppositely each other with respect to the identical source codes in the pair of code groups.

[0135] Figures 14A and 14B are a flowchart of an embodiment of a method of generating code groups for the (1, 8, 8, 12) code using the RLL code group generation method of Figures 5A and 5B. Since the steps S153 through S163, and the steps S169 and S170 are the same compared to Figures 5A and 5B, the explanation will be omitted. The differences with Figures 5A and 5B will now be described mainly focusing on steps S151 and S152, and steps S164 through S168.

[0136] In step S151, input is carried out, so that the minimum run length (d) is 1,

the maximum run length (k) is 8, the length of data bits (m) is 8, the length of code word bits (n) is 12, the main code group division parameter(x) is 1, and

the code word duplication parameter (y) is 3. In step S152, 2^n (i = 0~ 2^n -1) code words which satisfy the constraints input in the step S152 are generated, that is, 2^{12} code words are generated.

[0137] In the meantime, when the LZ value satisfies LZ ≤ k - y, bits from the least significant bit (bit0) to the most significant bit (bit11) are checked in step S164. It is determined whether the most significant bit (bit11) is "1" (10xxb: LZ =0) or the upper significant four bits (bit11 ~ bit8) are all "0" (000b: LZ =4 or 5) in step S165. If the most significant bit (bit11) is "1" or the upper significant four bits (bit11 ~bit8) are all "0," the code word is stored in the DCG1 in step 166. Otherwise (010xb(LZ =1), 0010b (LZ =1), or 0001b (LZ =3)), the code word is stored in the DCG2 in step S167. The code words which satisfy LZ =1 are stored in the DSV code group so that the code words have opposite CSV signs and INV characteristics while having the same position as the MCG2 code words in step S168.

[0138] Figures 15A through 15E are a main conversion table by code group (MCG1, MCG2, DCG1, DCG2) for the (1, 8, 8, 12) code generated by the algorithm of Figures 14A and 14B, and the characteristics of each code group are the same as Figure 6B. However, the two decision code groups DCG1 and DCG2 are allocated in the manner in which code words that satisfy LZ is 0, 4, or 5 are allocated in the DCG1 and code words that satisfy LZ is 1, 2, or 3 are allocated in the DCG2, and both groups' code words are allocated in the same positions as MCG1 and MCG2 code words which correspond to the same source words so that errors can be reduced when demodulating.

[0139] Figure 16 is a main conversion table for DSV control which includes 70 code words that exist in the MCG1 of Figures 15A through 15E and are specially parted for DSV control. The conversion table is generated in order that the code words of the conversion table have the opposite CSV and INV parameters with respect to the code words of the MCG2.

[0140] Figures 17A through 17E are a sub conversion table for DSV control for use instead of the main conversion table of Figures 15A through 15E at a DSV control point when a DSV control bit is inserted into a code word to be modulated.

[0141] Each code word in the sub conversion table is made by adding 1 merge bit to a code word in the main conversion table of Figures 15A through 15E. The 1 bit is allocated in the MSB of a code word, and the value of the 1 bit is represented by x which means "0" or "1" can be selected in order not to violate the run length constraint.

[0142] Figure 18 illustrates the result of computer simulation of the DC performance of a code word by using only the main conversion table of Figures 15A through 16. The result indicates that the code word itself has a DC suppression effect without using merge bits.

[0143] Figure 19 illustrates that the code group pairs (the MCG1 and the MCG2, or the MCG2 and the DSV code group) can control DC suppression and DC suppression capability when code words have opposite CSV and INV parameters (represented by a solid line) can be expected to have an additional suppression effect of about 2-3dB compared to DC suppression capability when code words have only opposite CSV signs (represented by a dotted line).

[0144] Figure 20 illustrates that DC suppression capability when a DSV code group is prepared separately and used (represent by a solid line) can be expected to have additional suppression effect of about 2dB compared to DC suppression capability when a DSV code group is not used (represented by a dotted line).

[0145] Figure 21 illustrates the result of computer simulation of the DC performance of a code word according to the frequency of DSV control (the frequency of usage of the sub conversion table for DSV of Figures 17A through 17E) when random data is input. Show from top to bottom are the power spectrum when the sub conversion table for DSV control is used once for every 8 code words; the power spectrum when the sub conversion table for DSV control is used once for every 4 code words; and the power spectrum when the sub conversion table for DSV control is used once for every 2 code words. As shown in Figure 21, the low-frequency component of a code is decreased but the recording density of a code is lowered, as the frequency of usage of the sub conversion table for DSV control of Figures 17A through 17E is higher.

[0146] Next, a modulation method and a demodulation method of the (1, 8, 8, 12) code using the code conversion table divided into code groups of Figures 7A through 9E, which is generated by the method of Figures 5A through 5B, and the code conversion table divided into by code group of Figures 15A through 17E, which is generated by the method of Figures 14A and 14B, will now be described.

[0147] Figures 22A and 22B are a flowchart of an embodiment of a method of modulating an RLL code represented by the (1, 8, 8, 12) code according to the present invention, and will be described referring to Figures 7A through 9E.

[0148] First, ncg is initialized to "1", and frequency numbers of DSV code insertion are set in step S201.

[0149] Here, as for the meaning of the frequency numbers, "0" means that code words for DSV control are not used, that is, the sub conversion table for DSV control of Figures 9A through 9E is not used. "1" means that the DSV control bit is inserted in every code word, and in this case, encoding is carried out by using the sub conversion table for DSV control without using the main conversion tables of Figures 7A through 8. "2" means that the sub conversion table for DSV control is used once for every two code words, and in this case, encoding is carried out by using alternately the main conversion tables and the sub conversion table for DSV control. "4" means that the sub conversion table for DSV control is used once for every four code words.

[0150] Undoubtedly, when the frequency of usage of the sub conversion table for DSV control is higher, redundancy in code words increases, which causes disadvantage though it is advantageous in DSV control.

[0151] After the ncg is initialised to "1" and the frequency number of DSV code insertion are input in the step S201, it is determined whether a synchronization code is inserted in step S202. Examples of synchronization code words are shown in Figure 23.

[0152] Figure 23 illustrates 24-bit synchronization code words which can be used in modulating (1, 8, 8, 12) by using the code conversion tables of Figures 7A through 9E. For the synchronization code words, a case when ncg points out the MCG1 and the DCG2 is distinguished from a case when ncg points out the MCG2 and the DCG1. The synchronization code words are allocated in order that the synchronization code words used when the ncg points out the MCG1 and DCG2 have the opposite CSV signs compared to the synchronization code words used when ncg points out the MCG2 and DCG1, in order to select synchronization code words which are advantageous to DSV control.

[0153] Figure 24 illustrates synchronization code words which can be used in modulation when the code conversion tables of Figures 15A through 17E are used.

[0154] A case when the ncg points out the MCG1 and the DCG1 is distinguished from a case when the ncg points out the MCG2 and the DCG2. The synchronization code words are allocated in order that the synchronization code words used when ncg points out the MCG1 and DCG1 have the opposite CSV signs with respect to the synchronization code words used when ncg points out the MCG1 and DCG2, in order to select synchronization code words which are advantageous to DSV control.

[0155] In the meantime, if the result of the step 202 indicates a synchronization code word insertion point, a synchronization code word insertion routine, in which a synchronization code word advantageous to DC suppression is selected, is performed in step S203, and whether or not data is the last one is determined in step S221. If it is determined that data is not the last data, the step S202 for determining whether to insert a synchronization code word is performed in the step S202. In Figures 22A and 22B, mc means a code word to be modulated, and DCC means to select which is advantageous to DC control.

[0156] A rule that a code word which follows a synchronization code word must be selected in a predetermined code word group is required. Therefore, in an embodiment of the present invention, the ncg which points out a code

word following a synchronization code word is 2, and a code word following a synchronization code word is selected in the MCG2.

[0157] If the result of the step 202 indicates that it is not a synchronization code word insertion point, input data is read in units of 1 byte in step S204. Then it is determined a DSV code insertion point in step S205, and if the result indicates that it is not a DSV code insertion point, the main conversion tables of Figures 7A through 8 are referred to a code group in step S206.

[0158] A modulated code word corresponding to the read 1 byte is selected in the code group corresponding to the ncg pointed out by the preceding code word in step S207. But, for DC suppression, two conversion code groups can be referred to when the ncg is 1 or 2.

[0159] First, when the ncg of the preceding code word is 1, a code word to be modulated can be selected by referring to both the MCG1 and the MCG2 when the preceding code word is not duplicated and the EZ of the preceding code word satisfies $1 \leq EZ \leq 3$, or the (1, 8) run length constraint is not violated when the EZ of the preceding code word satisfies $EZ > 3$ in steps S208 and S209. At this time, the selection criterion of a code group is a code group which includes a code word advantageous to DC control. Therefore, an mc is selected from one that is advantageous to DC control between the MCG1 and the MCG2 and the ncg is updated with an ncg pointed out by the code word in the selected code group in the step S209.

[0160] Here, when a code word whose EZ value satisfies $1 \leq EZ \leq 3$ is to be duplicated, the code word is not duplicated if $EZ = 1$ and the value of the upper significant 4 bits is 8 (1000b) or 9 (1001b), and ncg (=1) is generated in the manner, in which not the DCG1 or the DCG2, but the MCG1 or MCG2 is the code group which includes a following code word in order to control DSV effectively.

[0161] In the meantime, the ncg of the preceding code word is 1 and the code word in the MCG2 does not satisfy the (1, 8) run length, mc is selected in the MCG1, and the ncg is updated with the ncg pointed out by the code word selected in step S210.

[0162] If the ncg of the preceding code word is 2, the EZ of the code word is $EZ = 0$.

[0163] In this case, if the read data (dt) is less than 70, mc can be selected from one of the MCG2 and the DSV code group, and the ncg is updated with the ncg pointed out by the selected code word in steps S211 and S212. At this time, the selection criterion of a code group is a code group which is advantageous to DC suppression. If the read data (dt) is equal to or more than 70, mc is selected from the MCG2 and the ncg is updated with the ncg pointed out by the selected code word in step S213.

[0164] When the ncg of the preceding code word is 3 or 4, if the EZ of the preceding code word is $1 \leq EZ \leq 3$ and the preceding code word has a duplicate code word, the next code word is selected from one of the DCG1 and the DCG2, and the ncg is updated with the ncg pointed out by the selected code word in steps S214 and S215.

[0165] In Figure 22B, cod1(dt) means that a code word to be modulated corresponding to input data is selected from the MCG1; cod2(dt) means that a code word to be modulated corresponding to input data is selected from the MCG2; cod3(dt) means that a code word to be modulated corresponding to input data is selected from the DCG1; cod4(dt) means that a code word to be modulated corresponding to input data is selected from the DCG2; and cod5(dt)means that a code word to be modulated corresponding to input data is selected from the DSV code group.

[0166] In the meantime, if the result of the step S205 indicates that it is at a DSV code inserting point, encoding of data is carried out by using the sub conversion table for DSV control (Figures 9A through 9E) without using the main conversion table in step S216. Here, the tables of Figures 12A through 13C can be used as a sub conversion table for DSV control.

[0167] The ncg of the preceding code word is checked in step S217. If the ncg points out "1" or "2", both the MCG1 and the MCG2 in the sub conversion table for DSV control can be used, and in the MCG1 and the MCG2 of the sub conversion table for DSV control a code word where x exists can use x as both "0" and "1". Therefore, final code selection is made from DCC(DCC(cod*1(dt))), DCC(DCC(cod*2(dt)) in step S218.

[0168] In Figure 22A, cod*1(dt) means that a code word is selected from the MCG1 of the sub conversion table for DSV; cod*2(dt) means that a code word is selected from the MCG2 of the sub conversion table for DSV; cod*3(dt) means that a code word is selected from the DCG1 of the sub conversion table for DSV; and cod*4(dt) means that a code word is selected from the DCG2 of the sub conversion table for DSV. The mark * means that a plurality of code words can be generated in a corresponding code group. In addition, DCC(cod*1(dt)) means that since x (don't care) bit exists in the MSB of a code word and both "0" and "1" can be used for the bit when the sub conversion table of Figures 9A through 9E is used, a code word advantageous to DC suppression is selected.

[0169] When the ncg is 3 or 4, DSV control is impossible if a DSV control bit is not inserted (when the main conversion table is used), while DSV control is possible if a DSV control bit is inserted (when the sub conversion table for DSV control whose MSB is x is used). Therefore, when the ncg of the preceding code word points out "3" and "4", the DCG1 and the DCG2 of the sub conversion table for DSV are selected respectively, and "0" or "1" is selected for the don't care bit MSB to have better DSV control. Accordingly, when the ncg points out "3" and "4", final code selection is made by selecting an advantageous code word in DCC(cod*3(dt)) and DCC(cod*4(dt)), respectively.

[0170] Figure 25 illustrates a table in which the code groups pointed out by ncgs are divided into two cases; at a point which is not a point of inserting a code word for DSV control and at a point of inserting a code word for DSV control. At a point which is not a point of inserting a code word for DSV control, the main conversion tables of Figures 7A through 8 are used during modulation and demodulation, while at a point of inserting a code word for DSV control, the sub conversion table for DSV control (for example, Figures 9A through 9E) is used during modulation and demodulation.

[0171] That is, at a point which is not a point of inserting a code word for DSV control, the code group which includes the next code word is the MCG1 or the MCG2 if the ncg is 1; the MCG2 or the DSV code group if the ncg is 2; the DCG1 if the ncg is 3; and the DCG2 if the ncg is 4.

[0172] At a point of inserting a code word for DSV control, the same code group as at a point which is not a point of inserting code word for DSV control is selected if the ncg is 1, 3, or 4. But, if the ncg is 2, the code group which includes the next code word is the MCG1 or the MCG2.

[0173] Figures 26A and 26B are a flowchart for describing an embodiment of the method, according to the present invention, for demodulating the (1, 8, 8, 12) code using the code conversion tables of Figures 7A through 9E, and will now be described with reference to a demodulation apparatus of Figure 27 having shift registers SR2, SR1, SR0, and SR denoted by 102, 104, 106 and 108 respectively, a synchronization detection and protection unit 110, a 1st bit checking unit 112, an ncg extracting and changing unit 114, a detector 116, a 2nd bit checking unit 118, a logic circuit 120, a 3rd bit checking unit 122, and a demodulation code table 124.

[0174] The frequency number of DSV code insertion is input, and a code word stream which is input serially is shifted and stored in the shift registers 108, 106, 104, and 102 of Figure 27 in step S301.

[0175] The synchronization detection and protection unit 110 detects synchronization code by decoding the 24-bit synchronization pattern, as illustrated in Figure 23, supplied from the shift registers 102 and 104. When a synchronization pattern is detected by the synchronization detection and protection unit 110 in step S302, a synchronization restoration routine for synchronization protection and insertion is carried out, and the ncg following the synchronization pattern is updated with 2 in step S303, and it is determined whether data is the last data in step S318. That is, when the synchronization pattern detected in the synchronization detection and protection unit 110 is a normally detected synchronization pattern, the synchronization pattern is used as it is, and otherwise a pseudo synchronization pattern supplied by the synchronization detection and protection unit 110 is inserted in the step S303.

[0176] The way to find an ncg indicating a code group which includes a code word supplied from the shift register 106 which stores a code word to be demodulated will now be described.

[0177] After determining whether or not a code word stored in the shift registers and 102 and 104 is a synchronization pattern in the step S302, it is determined whether at a point of inserting a DSV code or not. At a point of inserting a DSV code, a DSV control bit which is allocated at the most significant bit in a code word is removed when the sub conversion table for DSV control of Figures 9A through 9E is used in step S305. Here, when the sub conversion tables for DSV control of Figures 12A through 13C are used, the DSV control bit is not removed and demodulation is carried out in the same manner as in the steps S306 through S318 for demodulating modulated codes.

[0178] Here, a DSV control signal (DSV time) supplied to the shift register 108 and the demodulation code table 124 is enabled when a counted number becomes the same value as the frequency of DSV code insertion, which is input in the step S301, after counting starts after a synchronization pattern is detected. When the sub conversion table for DSV control of Figures 9A through 9E is used, since the MSB of a code word is a DSV control bit and the remaining 12 bits are the same as in the main conversion table of Figures 7A through 7E, the main conversion table of Figures 7A through 7E can be used after removing the MSBs. That is, a code word bit stored in the higest bit (bit12) of the shift register 108 is removed when a DSV time signal is enabled.

[0179] At a point which is not a point of inserting DSV code in the step S304, the EZ value of the preceding code word supplied from the shift register 104 is checked in step S306, and when the EZ value is 0, the ncg is updated with 2 in step S307.

[0180] When EZ satisfies $1 \leq EZ \leq 3$, whether two duplicated code words exist in the code group pointed out by the ncg of the preceding code word is checked in step S308.

[0181] If two duplicated code words the same as the preceding code word stored in the shift register 104 exist in the code group pointed out by the ncg of the preceding code word in the step S308, the 9th bit (bit9) and the 5th bit (bit5) in the current code word to be demodulated in the shift register 106 are checked in step S309. If one of the two bits is a "1" bit, the ncg is updated with 3, and if both are "0", the ncg is updated with 4 in steps S310 and S311.

[0182] In the step S308, if the EZ of the preceding code word satisfies $1 \leq EZ \leq 3$ and there is no duplicated code word in the code group pointed out by the ncg of the preceding code, or if the EZ satisfies EZ >3, the ncg is updated with "1" in step S312.

[0183] That is, when the 1st bit checking unit 112 checks the lower significant 4 bits of the preceding code word in the shift register 104, the ncg CON signal is output as "01b" (meaning that the ncg is 2) if the EZ value is "0" (when bit 0 is "1"); the ncg CON signal is output as "10b" (meaning that the ncg is 3 or 4) if the EZ value satisfies $1 \leq EZ \leq 3$; and

ncg CON signal is output as "00b" (meaning that the ncg is "1") if the EZ value is equal to or greater than 4.

[0184] In the meantime, the 2nd bit checking unit 118 checks the upper significant 4 bits (bit 11 ~bit 8) of the preceding code word supplied from the shift register SR0 104, and supplies a logic "high" signal to the logic circuit 120 if "1000b" or "1001b" is found.

[0185] The detector 116, which includes a delay unit, supplies a logic "high" signal to the logic circuit 120 when "00b" is detected in outputs from the ncg extracting and changing unit 114.

[0186] The logic circuit 120 supplies an exception signal to the ncg extracting and changing unit 114 by enabling the exception signal if the upper significant 4 bit value of the shift register 104 is "1000b" or "1001b" and the ncg pointed out by the preceding code word stored in the shift register 104, detected by the detector 116, is "00b" (meaning that the ncg is 1). The ncg extracting and changing unit 114 changes the ncg CON signal "10b" (meaning that the ncg is 3 or 4) into "00b" and outputs "00b" according to the enabled exception signal, while output the ncg CON signal without changing to the demodulation code table 124 if the exception signal from the logic circuit 120 is disabled, or if the ncg CON signal is not "10b".

[0187] But, if the ncg CON signal is "10b", the ncg extracting and changing unit 114 checks the 9th bit and the 5th bit in the code word stored in the shift register 106 and to be demodulated, and outputs "10b" (meaning that the ncg is 3) to the demodulation code table 124 if one of the two bits is "1", and outputs "11b" (meaning that the ncg is 4) to the demodulation code table 124 if both bits are "0".

[0188] The reason why the ncg extracting and changing unit 114 changes the ncg CON signal from "10b" to "00b" is to obtain "1" (ncg CON = 00b), which makes the ncg of a code word which is not duplicated be the MCG1 or the MCG2, if the EZ is 1 and the value of the upper significant 4 bits is 8 (1000b) or 9 (1001b) when a code word whose EZ satisfies $1 \leq EZ \leq 3$ is being duplicated.

[0189] Next, a process for demodulating the output of the shift register 106 which stores a code word to be demodulated will now be described.

[0190] It is checked whether or not two code words exist in the code group indicated by the updated ncg in step S313. If two duplicated code words exist in the step S313, the 3rd bit checking unit 122 checks the 9th bit (bit 9) and the 5th bit (bit 5) of the next code word supplied from the shift register 108 in step S314. If one of the two bits is "1", it is determined that the current code word to be demodulated supplied from the shift register 106 is the first code word of the two duplicated code words, and the current code word is demodulated into the original data in step S315.

[0191] If both the 9th bit (bit 9) and the 5th bit (bit 5) of the next code word supplied from the shift register 108 are "0" in the step S314, it is determined that the current code word to be demodulated supplied from the shift register 106 is the second code word in the two duplicated code words, and the current code word is demodulated into the original data in step S316.

[0192] If only one code word of the code group pointed out by the updated ncg in the step S313 is the same as the current code word supplied from the shift register 106, a code word in the code group pointed out by the updated ncg is demodulated into the original data corresponding to the current code word to be demodulated supplied from the shift register 106 in step S317.

[0193] As illustrated in Figure 25, at a point which is not a point of inserting a code word for DSV control, a code group which includes the next code word is the MCG1 or the MCG2 if the ncg is 1; the MCG2 or the DSV code group if the ncg is 2; the DCG1 if the ncg is 3; and the DCG2 if the ncg is 4. At a point of inserting a code word for DSV control, a code group which includes the next code word is the MCG1 or the MCG2 if the ncg is 1 or 2; the DCG1 if the ncg is 3; and the DCG2 it the ncg is 4.

[0194] For example, if a DSV time signal is enabled in the demodulation code table 124 (meaning a point of inserting a code word for DSV control) and the signal supplied from the ncg extracting and changing unit 114 is "00b", selection is performed from one of the MCG1 and the MCG2.

[0195] Regardless of the DSV time signal, the demodulation code table 124 selects from the MCG1 or the MCG2 if the signal supplied from the ncg extracting and changing unit 114 is "00b"; from the MCG2 or the DSV code group in the signal is "01b"; from the DCG1 if the signal is "10b"; and from the DCG2 if the signal is "11b".

[0196] But, if the signal supplied from the ncg extracting and changing unit 114 is "10b" or "11b", the 9th bit (bit 9) and the 5th bit (bit 5) of the next code word in the sift register 108 are checked, and the first code word of the two duplicated code words is selected when there is "1" in the 9th and 5th bits, and otherwise the second code word of the two duplicated code words is selected. In this manner, the original 8-bit data is restored from the demodulation code table 124 according to the 12 bits in a code word stored in the shift register 106 and to be demodulated.

[0197] Figures 28A and 28B are a flowchart for describing another embodiment of the method, according to the present invention, for demodulating the (1, 8, 8, 12) code using the code conversion tables of Figures 15A through 17E. Since steps S351~S357, S363, S367, and S368 are the same as steps in Figures 26A and 26B, the description will be left out. Steps S358 through S361 and S364 through S366 will now be described.

[0198] It is checked whether the preceding code word is included in the MCG1 (ncg =1) and whether the upper significant 4 bits is 8 (1000b) or 9 (1001b) in step S358. All bits of a code word to be demodulated are checked in step

S359. If the LZ of the code word to be demodulated is 0, 4, or 5, the ncg is updated with 3 in step S360, and if the LZ of the code word to be demodulated is 1, 2, or 3, the ncg is updated with 4 in step S361.

[0199] Bits of the succeeding code word are checked in step S364. If the LZ of the succeeding code word is 0, 4, or 5, it is determined that the current code word to be demodulated is the first code word in the duplicated code words, and the corresponding original data is demodulated from the first code word in step S365. If the LZ of the succeeding code word is 1, 2, or 3, it is determined that the current code word to be demodulated is the second code word in the duplicated code words, and the corresponding original data is demodulated from the second code word in step S366.

[0200] A synchronization pattern checked in step S352 is a 24-bit synchronization pattern of Figure 24.

[0201] Figure 29 is a demodulation apparatus for performing the demodulation method of Figures 28A and 28B. Since the operations of shift registers 152 through 158, a 1st bit checking unit 162 and a 2nd bit checking unit 168, a detector 166, and a logic circuit 170 are the same as in the demodulation apparatus of Figure 27, the description will be left out. An ncg extracting and changing unit 164, a 3rd bit checking unit 172, and a demodulation code table 174 will now be described.

[0202] The ncg extracting and changing unit 164 receives an ncg CON signal supplied from the 1st bit checking unit 162. When the EZ value of the lower significant 4 bits in the preceding code word supplied from the shift register 154 is 0 (when bit 0 is 1), the ncg CON signal is "01b" (meaning that the ncg is 2); when the EZ value is between 1 and 3 (when bit3 ~ bit0 is 1000b, 0100b, 0010b, or 1010b), the ncg CON signal is "10b" (meaning that the ncg is 3 or 4); and when the EZ value is equal to or more than 4 (when bit3 ~ bit0 is 000b), the ncg CON signal is "00b" (meaning that the ncg is 1).

[0203] At this time, when the ncg CON signal is "10b", the ncg extracting and changing unit 164 supplies "10b" which indicates that ncg =3, to the demodulation code table 174 if the value of the upper significant 4 bits of the current code word supplied from the shift register 156 is 10xxb (LZ =0) or 0000b (LZ =4, or 5); and supplies "11b", which indicates that ncg =4, to the demodulation code table 174 if the value of the upper significant 4 bits of the current code word supplied from the shift register 156 is 010xb (LZ =1), 0010b (LZ =2) or 0001b (LZ =3).

[0204] In the meantime when the value of the upper significant 4 bits (bit 11 ~bit 8) in the preceding code word which is checked by the 2nd bit checking unit 168 is "8" (=1000b) or "9" (=10001b), an exception signal is enabled if the previous ncg CON signal is "00b" (when the ncg of the preceding code word stored in the shift register 104 is 1). At this time, if the ncg CON signal supplied from the 1st bit checking unit 162 is "10b", the ncg CON signal is changed into "00b" and "00b" is output. If the exception signal is disabled or the ncg CON is not "10b", the ncg CON signal is supplied to the demodulation code table 174 without change.

[0205] In the demodulation code table 174, the MCG2 or the DSV code group is selected when the DSV time signal is disabled and the signal supplied from the ncg extracting and changing unit 164 is "01b", and the MCG1 or the MCG2 is selected when DSV time signal is enabled (meaning that it is at a point of inserting a code word for DSV control) and the signal supplied from the ncg extracting and changing unit 164 is "01b".

[0206] Regardless of the DSV time signal, the MCG1 or the MCG2 is selected when the signal supplied from the ncg extracting and changing unit 164 is "00b"; the DCG1 is selected when the signal is "10b"; and the DCG2 is selected when the signal is "11b". But, when the signal supplied from the ncg extracting and changing unit 164 is "10b" or "11b", the 3rd bit checking unit 172 is referred. When the value of the upper significant 4 bits (bit 11 ~ bit 8) in the succeeding code word which is checked by the 3rd bit checking unit 172 is "10xxb" or "0000b", the first code word of duplicated code words is selected, and when the value is "0100b", "0101b", "0010b", or "0001b", the second code word of duplicated code words is selected. By doing so, using the demodulation code table 174 according to the 12 bits of the current code word supplied from the shift register 156, a code word is demodulated and the original 8-bit data is restored.

[0207] As described above, according to embodiments of the present invention, some of the code words which are already used in the main code group are used for the DSV code group for DC suppression, and the main code group is generated using the characteristics (for example, the CSV and INV parameters) of the code words of the main code group to the maximum, and thus reduces the number of code word bits to improve recording density and increases DC suppression capability.

[0208] By using the main code conversion table at a point which is not a point of a predetermined DSV control, or by using the sub code conversion table for DSV control at a point of a predetermined DSV control, the present invention has an effect of reducing the number of code word bits.

[0209] By using the sub conversion table for DSV control which is used at a point of a predetermined DSV control after forming the sub conversion table in order that the sub conversion table has code words separate to the main conversion table and the characteristics of code words in the main conversion table, that is, the signs of the CSV which indicates the DC value in a code word and the characteristic of the INV parameter which predicts the transition direction of the succeeding code word are maximized, the present invention has an effect of effectual DC suppression. At this time, by selecting the code group which includes the succeeding code word as the same code group, it becomes appropriate to be used in a code stream selection algorithm of a look-ahead method.

[0210] In addition, embodiments of the present invention enables DC suppression which is not possible in the (1,

7, 2, 3) code, and enables additional DC suppression by using DSV control bits. Thanks to these effects, code noise flowing into a servo system can be greatly reduced, and the problems in digitizing RF signals output from a pick-up are removed, and thus reliability of entire system is greatly increased.

[0211] The reader's attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

[0212] All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

[0213] Each feature disclosed in this specification (including any accompanying claims, abstract and drawings), may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

[0214] The invention is not restricted to the details of the foregoing embodiment(s). The invention extend to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

Claims

1. An allocating method for allocating code groups grouped by the characteristics of code words after generating a run length limited (RLL) code which is represented by (d, k, m, n), wherein d means the minimum run length, k means the maximum run length, m means the length of data bits, and n means the length of code word bits, the allocating method comprising the steps of:

   allocating a pair of code groups for controlling direct current (DC) suppression in a code word stream; and

   allocating code words to the pair of code groups, the code words corresponding to the same source code, in order that the corresponding code words of each of the code groups have opposite signs of a 1^{st} parameter, code word sum value (CSV), which represents the DC value in a code word and opposite characteristics of a 2^{nd} parameter INV which predicts the transition direction of the digital sum value (DSV) of the succeeding code word.

2. The allocating method of claim 1 or claim 2, wherein code words in each of the pair of code groups, the code words corresponding to the same source code, are arranged in order that the code words have opposite signs of the 1^{st} parameter and opposite characteristics of the 2^{nd} parameter, and the corresponding code words of each of the code groups are made to select the same code group as a code group which includes the succeeding code word so that the digital sum value (DSV) direction of a code stream goes oppositely each other with respect to the identical source codes in the pair of code groups.

3. The allocating method of claim 1 or claim 2, wherein code words in a reference code group in the pair of code groups are arranged so that absolute value of their 1^{st} parameters (CSVs) are in descending order.

4. The allocating method of any of claims 1 to 3, wherein code words of the reference code group in the pair of code groups and code words of a code group which can control DC suppression are arranged so that the absolute value of their 1^{st} parameters (CSVs) are in descending order and code words corresponding to the same source codes of the reference code group are arranged in order that the code words have opposite signs of the 1^{st} parameter (CSV) and opposite characteristics of the 2^{nd} parameter (INV).

5. An allocating method of allocating code groups grouped by the characteristics of code words after generating run length limited (RLL) code which is represent by (d, k, m, n) wherein d means the minimum run length, k means the maximum run length, m means the length of data bits, and n means the length of code word bits, the allocating method comprising the steps of:

   allocating a pair of code groups which can control direct current (DC) suppression in order to control suppression of DC in a code word stream; and

   allocating code words in the pair of code groups, the code words corresponding to the same source code, so

that the code words have the opposite characteristics of a 2nd parameter INV which predicts the transition direction of the digital sum value (DSV) of the succeeding code word and the code words are made to select the same code group as a code group which includes the succeeding code word so that the DSV direction of a code stream goes oppositely and it is advantageous to use a code stream selection algorithm of a look-ahead method.

6. An allocating method of allocating code groups grouped by the characteristics of code words after generating run length limited (RLL) code which is represent by (d, k, m, n) wherein d means the minimum run length, k means the maximum run length, m means the length of data bits, and n means the length of code word bits, the allocating method comprising the steps of:

allocating a main code group defined as a code group which include a code word following a not-duplicated code word, and a decision code group defined as a code group which includes a code word following a duplicated code word;

allocating code words of the main code group so that a code word whose lead zero (LZ) number is less than or equal to a main code group division parameter (x) is allocated to a 1st main code group, and a code word whose LZ number is greater than the main code group division parameter (x) is allocated to a 2nd main code group, and there are no the same code words between in the 1st main code group and the 2nd code group; and

allocating code words of the decision code group so that the decision code group is formed with code words which satisfy that LZ is equal to or less than the difference value of the maximum run length (k) and a code word duplication parameter (y) and the code words are allocated to one of a 1st decision code group and a 2nd decision code group according to the value of predetermined bits in each code word.

7. The allocating method of claim 6, wherein code words which satisfy that LZ ≤ 3 and the 9th bit or the 5th bit of a code word are "1" are allocated to the 1st decision code group, and code words which satisfy that LZ ≤ 3 and the 9th bit and the 5th bit of a code word are both "0" are allocated to the 2nd decision code group, and there are no the same code words between in the 1st decision code group and the 2nd decision code group.

8. The allocating method of claim 6 or claim 7, wherein when the 11th bit in a code word is referred to as the most significant bit and 0th bit in a code word is referred to as the least significant bit, if the most significant bit is "1" or the upper significant 4 bits are all "0", that is, if a code word satisfies that the LZ of the upper significant 4 bits is 0, 4, or 5, the code word is allocated to the 1st decision code group, and if a code word satisfies that the LZ of the upper significant 4 bits is 1, 2, or 3, the code word is allocated to the 2nd decision code group.

9. The allocating method of any of claims 6 to 8, wherein as a separate code group for suppression of DC in a code stream, a DSV code group which comprises code words extracted from one of the main code groups is additionally included.

10. The allocating method of claim 9, wherein the DSV code group is formed so that, though a code word which includes the next code is the 1st main code group, code words which are included in the 2nd main code group and have possibility of not violating the (d, k) run length constraint are extracted, and the code words are allocated to have the opposite signs of a 1st parameter code word sum value (CSV) which represents the direct current (DC) value in a code word and the opposite characteristics of a 2nd parameter INV which predicts the transition direction of the digital sum value (DSV) of the succeeding code word with respect to code words which are included in the 1st main code group and correspond to the same source codes, and the DSV code group together with the 1st code group additionally controls DC suppression.

11. The allocating method of claim 9, wherein the DSV code group is formed so that, though a code word which includes the next code is the 2nd main code group, code words which are included in the 1st main code group and have possibility of not violating the (d, k) run length constraint are extracted, and the code words are allocated to the code group for DSV control to have the opposite signs of the 1st parameter (CSV) and the characteristics of the 2nd parameter (INV) with respect to code words which are included in the 2nd main code group and correspond to the same source codes, and the DSV code group together with the 2nd main code group additionally control DC suppression.

12. The allocating method of claim 11, wherein the DSV code group is formed with code words which satisfy LZ is 1,

and code words whose number of end zeros is "0" are made to indicate the 2nd main code group as a code group which includes the succeeding code word, and the code words are allocated to have the opposite signs of the 1st parameter (CSV) and the opposite characteristics of the 2nd parameter (INV) with respect to code words which are included in the 2nd main code group and correspond to the same source codes, and the DSV code group together with the 2nd main code group can control suppression of DC in a code word stream.

13. A modulation method for modulating data input to optical disc recording/reproducing apparatuses to a run length limited (RLL) code which are represented by (d, k, m, n) wherein d means the minimum run length, k means the maximum run length, m means the length of data bits, and n means the length of code word bits, the modulation method comprising the steps of:

(a) at a point DSV control, modulating m-bit data input with inserting a code word for DSV control, and otherwise, modulating m-bit data input with selecting a code word of one code group in main code groups, in which code words have duplicated code words and code words of each code group are allocated to have the opposite signs of a 1st parameter code word sum value (CSV) which represents direct current (DC) value in a code word and the opposite characteristics of a 2nd parameter (INV) which predicts the transition direction of digital sum value (DSV) of the succeeding code word, and decision code groups for determining whether a code word is the duplicated code word.

14. The modulation method of claim 13, wherein, when it is not at a point of DSV control, one or more DSV code group which is formed with some or all code words of one main code group in the main code groups and is for DSV control is used for modulation.

15. The modulation method of claim 13 or claim 14, wherein if it is the point of DSV control set by the frequency number of inserting a code word for DSV control, input data is modulated into a code word for DSV control, and otherwise, the input data is modulated into a code word of one code group among the main code groups, the decision code groups, and the DSV code group.

16. The modulation method of any of claims 13 to 15, wherein the main code groups include the 1st main code group and the 2nd main code group that are a pair of code groups which can control DC suppression; the decision code groups include the 1st decision code group and the 2nd decision code group; and the DSV code group includes some or all of the code words in one of the 1st main code group and the 2nd code group and allocate the code words so that the code words have the opposite signs of the 1st parameter and the opposite characteristics of the 2nd parameter with respect to corresponding code words which are included in the 2nd main code group or the 1st main code group and correspond to the same source codes, and then DC suppression is performed.

17. The modulation method of any of claims 13 to 16, the method further comprising the steps of:

(b) checking the number of end zeros (EZ) of the selected code words; and

(c) if $EZ \leq d-1$, making a 3rd parameter (ncg), which indicates a code group of a code word following a code word of the each code group, to point out the 2nd main code group or the DSV code group; if $d \leq EZ \leq y$ (y: code word duplication parameter) and the code word is duplicated, making the 3rd parameter to point out the 1st decision code group or the 2nd decision code group; and if $y \leq EZ \leq k$ or $d \leq EZ \leq y$ and the code word is not duplicated, making the 3rd parameter to indicate the 1st main code group or the 2nd main code group, wherein unless the maximum run length k is violated, code word selection scope can be widened to enhance DC suppression capability.

18. The modulation method of claim 17, wherein for the (1, 8, 8, 12) code, d, k, m, and n are set to 1, 8, 8, 12, respectively, and x that is a division parameter for distinguishing the 1st main code group and the 2nd main code group is set to 1, and y that is a parameter for duplicating a code word is set to 3.

19. The modulation method of claim 17, the method further comprising a step:

(d) inserting a synchronization pattern every predetermined cycle; wherein synchronization patterns, which are used when the 3rd parameter points out the 1st main code group or the 2nd decision code group, and synchronization patterns, which are used when the 3rd parameter points out the 2nd main code group or the 1st decision code group, are allocated to have opposite signs of the 1st parameter and opposite characteristics of the

2nd parameter in order to select a synchronization code word advantageous to DSV control.

20. The modulation method of claim 17 or claim 18 or claim 19, the method further comprising a step:

(d) inserting a synchronization pattern every predetermined cycle; wherein synchronization patterns, which are used when the 3rd parameter points out the 1st main code group or the 1st decision code group, and synchronization patterns, which are used when the 3rd parameter points out the 2nd main code group or the 2nd decision code group, are allocated to have opposite signs of the 1st parameter and opposite characteristics of the 2nd parameter in order to select a synchronization code word advantageous to DSV control.

21. The modulation method of any of claims 17 to 20, wherein the code group pointed out by the 3rd parameter changes depending on whether at a point of DSV control or not, that is, when the number of end zeros is less than the minimum run length, at a point of DSV control, the code group pointed out by the 3rd parameter is the 1st main code group or the 2nd main code group in order to select a code word advantageous to DSV control, and if it is not at a point of DSV control, the code group pointed out by the 3rd parameter is the 2nd main code group or the DSV code group in order to select a code word advantageous to DSV control.

22. The modulation method of any of claims 13 to 21, wherein in the step (a), at a point of DSV control, m-bit input data is modulated by using the sub conversion table for DSV control whose code words are added with bits for DSV control in order to more strongly suppress DC component in a code word stream.

23. The modulation method of claim 22, wherein the code words of the sub conversion table for DSV control are made by adding predetermined merge bits to the same code words in the main code groups and the decision code groups.

24. The modulation method of claim 22 or claim 23, wherein the code words of the sub conversion table for DSV control points out the same code word groups as the main code groups and the decision code groups.

25. The modulation method of any of claims 22 to 24, wherein code words of the sub conversion code table are made by adding a DSV control bit to the code words of the main code groups and the decision code groups as MSB.

26. The modulation method of claim 16, wherein the 1st main code group is comprised of code words whose LZ is less than or equal to the main code group division parameter (x) "1", and the 2nd main code group is comprised of code words whose LZ is equal to or greater than 1, and the 1st main code group has no code words identical to any code word of the 2nd main code group and vice versa, and code words whose EZ is equal to or greater than the minimum run length (d) and less than or equal to the code word duplication parameter (y) are duplicated.

27. The modulation method of claim 26, wherein among code words whose EZ is equal to or greater than the minimum run length (d) and less than or equal to the code word duplication parameter (y), some code words are exceptionally not duplicated by checking a predetermined code group and bits of a code word in order to control more efficient DC suppression.

28. The modulation method of claim 26 or claim 27, wherein the exceptionally-not-duplicated code words do not select the 1st decision code group or the 2nd decision code group, but select the 1st main code group or the 2nd main code group as ncg.

29. The modulation method of any of claims 26 to 28, wherein code words whose EZ is $1 \leq EZ \leq 3$ are duplicated, however, code words whose EZ is "1" and the upper significant four bits of a code word is 8 (1000b) or 9 (1001b) are not duplicated, and the 3rd parameter (ncg) is made to point out not the 1st decision code group or the 2nd decision code group, but the 1st main code group or the 2nd main code group in order to perform advantageous DSV control.

30. A modulation method of modulating data input to optical disc recording/reproducing apparatuses to a run length limited (RLL) code which are represented by (d, k, m, n) wherein d means the minimum run length, k means the maximum run length, m means the length of data bits, and n means the length of code word bits, the modulation method comprising the steps of:

(a) setting a point of DSV control which indicates whether to repeatedly insert a code word for DSV control in a predetermined number of code words; and

(b) when it is not at a point of DSV control, modulating m-bit input data to an n-bit code word selected from the main conversion table, and at a point of DSV control, modulating m-bit input data to a code word selected from a sub conversion table for DSV control, the table comprised of code words longer than n-bit code words of the main conversion table.

31. The modulation method of claim 30, wherein the main conversion table is comprised of main code groups and decision code groups for determining whether a code word is duplicated or not, and the main code groups allocated code words so that a code word in a main code group has the sign of the 1st parameter code word sum value (CSV), which represent DC value in the code word, and the characteristic of the 2nd parameter INV, which predicts the transition direction of digital sum value (DSV) of the succeeding code word, both the sign and the characteristic opposite to those of corresponding code word in the other main code group.

32. The modulation method of claim 30 or claim 31, wherein the main conversion table additionally includes one or more DSV code groups which are comprised of some or entire code words of a main code group among the main code groups.

33. The modulation method of any of claims 30 to 32, wherein the sub conversion table for DSV control has four states, each state having code words, which are longer than the n-bit code words of the code groups of the main conversion table and different from the n-bit code words, and each state having two code groups, and the two code groups of each state have code words having a 1st parameter code word sum value (CSV), which represents DC value in a code word, opposite to the 1st parameter of the corresponding code word in the other code group in the same state.

34. The modulation method of claim 33, wherein the code words of the two code groups of each state select the same next code group which includes the succeeding code word.

35. The modulation method of any of claims 30 to 34, wherein the sub conversion table for DSV control has four states, each state having code words, which are longer than the n-bit code words of the code groups of the main conversion table and different from the n-bit code words, and each state having two code groups, the two code groups of each state have code words having a 2nd parameter (INV), which predicts the transition direction of digital sum value (DSV) of the succeeding code word, opposite to the 2nd parameter of the corresponding code word in the other code group in the same state.

36. The modulation method of claim 35, wherein the code words of the two code groups of each state select the same next code group which includes the succeeding code word.

37. The modulation method of any of claims 30 to 36, wherein the sub conversion table for DSV control is comprised of 14-bit code words which satisfy that d and k are 1 and 8, respectively.

38. A demodulation method of demodulating a code word stream received in optical disc recording/reproducing apparatuses using a Run Length Limited (RLL) code into original data, wherein at a point of DSV control, m-bit input data is modulated to a code word for DSV control, and when it is not at a point of DSV control, m-bit input data is modulated to a code word in one code group among main code groups and decision code groups, the main code groups having duplicated code words and having code words which have a 1st parameter code word sum value (CSV), which represents DC value in a code word, and the characteristic of a 2nd parameter INV, which predicts transition direction of digital sum value (DSV) of the succeeding code word, both opposite to those of the corresponding code words of the other main code group, and the decision code groups for determining whether a code word is the duplicated code words, the demodulation method comprising the steps of:

(a) updating a 3rd parameter, which points out the code group having the current code word to be demodulated, according to the characteristics of the previous code words after inputting a code word stream; and

(b) demodulating the code word into the corresponding original m-bit data in the code group pointed out by the updated the 3rd parameter when only one current code word exist in the code group pointed out by the updated the 3rd parameter (ncg).

39. The demodulation method of claim 38, further comprising a step of:

(c) checking predetermined bits of the succeeding code word when two duplicated code words exist in the code group pointed out by the updated 3rd parameter (ncg), and if any one bit in the checked bits is "1", demodulating the first code word in the duplicated code words into the original data, and if all bits are "0", demodulating the second code word in the duplicated code words into the original data.

40. The demodulation method of claim 38 or claim 39, further comprising a step of:

(c) when two duplicated code words exist in the code group pointed out by the updated 3rd parameter (ncg), if the number at lead zeros of the succeeding code word is 0, 4, or 5, demodulating the first code word of the duplicated code words into the original data, and if the number of lead zeros of the succeeding code word is 1, 2, or 3, demodulating the second code word into the original data.

41. The demodulation method of any of claims 38 to 40, further comprising a step of:

(c) restoring synchronization pattern after determining whether an input code word stream is synchronization pattern, and initializing the 3rd parameter (ncg) to one of the code groups.

42. The demodulation method of any of claims 38 to 41, further comprising a step of:

(c) when an input code word stream is a code word modulated during a point of DSV control, removing a DSV control bit and then performing the step (a).

43. The demodulation method of any of claims 38 to 42, further comprising a step of:

(c) when an input code word stream is a code word modulated at a point of DSV control, demodulating the code word by using an additional sub conversion table for DSV control.

44. The demodulation method of any of claims 38 to 43, wherein the RLL data modulated when it is not at a point of DSV control is modulated by using one or more DSV code groups, each DSV code group being comprised of some code words of the main code group.

45. The demodulation method of any of claims 38 to 44, wherein the step (a) comprising the sub-steps of:

(a1) determining the number of end zeros (EZ) in the preceding code word;

(a2) if the EZ of the preceding code word is "0", updating the 3rd parameter (ncg) as the 2nd main code group;

(a3) if the EZ of the preceding code word is "1", when it is not at a point of DSV control, updating the 3rd parameter (ncg) as either of the 2nd main code group or the DSV code group that are advantageous to DC control, and at a point of DSV control, updating the 3rd parameter (ncg) as either the 1st main code group or the 2nd main code group;

(a4) if the EZ of the preceding code word is equal to or greater than the minimum run length (d) and less than or equal to the code word duplication parameter (y), determining whether or not two duplicated code words exist in the code group pointed out by the 3rd parameter (ncg) of the preceding code word;

(a5) if two duplicated code words exist in the step (a4), checking predetermined bits of the current code word and updating the 3rd parameter as the 1st decision code group or the 2nd decision code group depending on whether the predetermined bits "1" or "0"; and

(a6) if the EZ of the preceding code word is greater than the duplication parameter and less than or equal to the maximum run length (k), or if the two duplicated code words do not exist in the step (a4), updating the 3rd parameter as either the 1st main code group or the 2nd main code group that are advantageous to DC control.

46. The demodulation method of claim 45, wherein if d is 1; k is 8; m is 8; n is 12; the division parameter (x) which divide the 1st main code group and the 2nd main code group is 1; the code word duplication parameter (y) is 3; and the predetermined bits are the 9th bit and the 5th bit, when any of the 9th bit and the 5th bit is "1" in the step (a5), the 3rd parameter (ncg) is updated as the 1st decision code group, and when all of the predetermined bits are "0", the 3rd

parameter (ncg) is updated as the 2nd decision code group.

47. The demodulation method of claim 45 or claim 46, if d is 1; k is 8; m is 8; n is 12; the division parameter (x) which divide the 1st main code group and the 2nd main code group is 1; the code word duplication parameter (y) is 3; and the predetermined bits are the upper significant 4 bits of the current code word, in the step (a5), when the most significant bit of the current code word is "1" or the upper significant four bits of the current code word are all "0", the 3rd parameter (ncg) is updated as the 1st decision code group, and otherwise the 3rd parameter (ncg) is updated as the 2nd decision code group.

48. A demodulation method of demodulating a code word stream received in optical disc recording/reproducing apparatuses using a run length limited (RLL) code into original data, wherein when it is not at a point of DSV control, m-bit input data is modulated to an n-bit code word selected from a main conversion table, and at a point of DSV control, m-bit input data is modulated to a code word which is selected from a sub conversion table for DSV control, the table being comprised of code words longer than n-bit code words of the main conversion table, the demodulation method comprising the steps of:

(a) determining whether a point of DSV control in a received code word stream or not, the point of DSV control when a code word for DSV control is inserted every predetermined number of code words; and

(b) when the result of the step (a) determines that it is not at a point of DSV control, demodulating an n-bit code word in the received code word stream into original m-bit data by using the 1st demodulation table corresponding to the main conversion table, and when the result of the step (a) determines a point of DSV control, demodulating a code word longer than n-bit into original m-bit data by using the 2nd demodulation table corresponding to the sub conversion table for DSV control.

49. A demodulation apparatus for demodulating an n-bit code word into the original m-bit data in optical disc recording/reproducing apparatuses using a run length limited (RLL) code represented by (d, k, m, n), wherein d means the minimum run length, k means the maximum run length, m means the data bit length, and n means the code word bit length, the demodulation apparatus comprising:

a shift register for storing the preceding code word, a current code word, and the succeeding code word in a received code word stream;

a detector for detecting the value of a 3rd parameter (ncg), which points out the next code group of the preceding code word, according to the number of end zeros (EZ) after checking the number of EZ of the preceding code word;

a determining unit for supplying a determination signal for determining whether or not a code word is duplicated, after checking a predetermined bit of the preceding code word; and

a demodulation code table for supplying m-bit data corresponding to the current code word in the code group pointed out by the 3rd parameter (ncg) of the preceding code word.

50. The demodulation apparatus of claim 49, wherein the demodulation code table comprises main code groups and decision code groups for determining whether or not duplicated code words exist, and the main code groups have duplicated code words and have code words which have a 1st parameter code word sum value (CSV), which represents DC value in a code word, and the characteristic of a 2nd parameter INV, which predicts transition direction of digital sum value (DSV) of the succeeding code word, both opposite to those of the corresponding code words of the other main code group, and m-bit data corresponding to the current code word is read from the code group pointed out by the 3rd parameter (ncg) of the preceding code word according to the 3rd parameter (ncg), the duplication code word determination signal, and a DSV control signal which indicates a point of DSV control.

51. The demodulation apparatus of claim 49 or claim 50, further comprising a synchronization detection and protection unit for detecting a synchronization pattern in an output from the shift register and using the detected synchronization pattern when the pattern is normally detected, and otherwise using pseudo synchronization pattern.

52. The demodulation apparatus of claim 51, wherein counting starts from the synchronization pattern detection, and at a point of DSV control corresponding to the frequency of inserting code word for DSV control, the most significant

bit is removed from the current code word and the code word is demodulated into original data by using the demodulation code table.

53. The demodulation apparatus of claim 51, wherein counting starts from the synchronization pattern detection, and at a point of DSV control corresponding to the frequency of inserting code word for DSV control, a code word to which a code word for DSV control is inserted is demodulated by using a separate demodulation code table for DSV control.

54. The demodulation apparatus of any of claims 50 to 53, wherein the detector comprising:

a 1st bit checking unit for checking the EZ of the preceding code word and supplying an ncg control signal pointing out the next code group according to the EZ value;

a 2nd bit checking unit for checking a predetermined number of highest bits of the preceding code word in order to detect a code word having an exception condition of duplicated code words, and supplying an exception control signal when the predetermined number is checked; and

an ncg extracting and changing circuit for changing the ncg control signal into a 1st state value when the exception control signal supplied from the 2nd bit checking unit and the ncg control signal supplied from the 1st bit checking unit are 3rd state values, and supplying the ncg control signals from the 1st and the 2nd state values supplied from the 1st bit checking unit, without change, when the 2nd bit checking unit does not supply the exception control signal or the ncg control signal is not a 3rd state value.

55. The demodulation apparatus of claim 54, wherein the ncg extracting and changing circuit, checking the lower significant four bits of the preceding code word, outputs the 3rd parameter (ncg) in the form of the 2nd state value when the EZ is 0;

in the form of the 3rd state value when the EZ is between 1 and 3; and in the form of the 1st state value when the EZ is equal to or greater than 4.

56. The demodulation apparatus of claim 54 or claim 55, wherein the demodulation code table reads the original data corresponding to the current code word from one code group among the decision code groups if the 3rd parameter (ncg) supplied from the ncg extracting and changing circuit is the 3rd state value.

57. The demodulation apparatus of claim 54 or claim 55, wherein the demodulation code table reads the original data corresponding to the current code word from one code group among the main code groups if the 3rd parameter (ncg) supplied from the ncg extracting and changing circuit is the 1st state value.

58. The demodulation apparatus of any of claims 54 to 57, wherein the demodulation code table additionally has one or more DSV code groups, each DSV code group being comprised of some or entire code words of a code group among the main code groups.

59. The demodulation apparatus of claim 58, wherein if the 3rd parameter (ncg) supplied from the ncg extracting and changing circuit is the 2nd state value and, at a point of DSV control according to the DSV control signal, the demodulation code table reads the original data corresponding to the current code word from a code group among the main code groups, and if it is not at a point of DSV control, the demodulation code table reads the original data corresponding to the current code word from a main code group whose code words have the opposite signs of the 1st parameter and the opposite characteristics of the 2nd parameter with respect to the code words of the DSV code group.

60. The demodulation apparatus of any of claims 54 to 59, wherein the 2nd bit checking unit checks whether the upper significant four bits of the preceding code word is 8 (1000b) or 9 (1001b); the determining unit checks whether the 9th bit and the 5th bit of the succeeding code word is "0" or "1"; and the demodulation code table selects one of two duplicated code words according to whether the 3rd parameter (ncg) is the 3rd state value and any of the 9th bit and the 5th bit is "1".

61. The demodulation apparatus of any of claims 54 to 59, wherein the 2nd bit checking unit checks whether the upper significant four bits of the preceding code word is 8 (1000b) or 9 (1001b); the determining unit checks whether the

upper significant four bits of the succeeding code word; and the demodulation code table selects one of two duplicated code words according to whether the 3rd parameter (ncg) is the 3rd state value and what is the number of lead zeros of the upper significant four bits.

62. The demodulation apparatus of any of claims 54 to 61, wherein the ncg extracting and changing circuit changes the 3rd state value of the ncg control signal supplied from the 1st bit checking unit into the 1st state value in order to make the 3rd parameter (ncg) of a not-duplicated code word point out one code group among main code groups when the EZ of the preceding code word is 1 and the upper significant four bits is 8 (1000b) or 9 (1001b).

63. The demodulation apparatus of any of claims 49 to 62, wherein d is 1, k is 8, m is 8, n is 12, and the RLL code is (1, 8, 8, 12) code.

SDOCID: <EP_____1047197A2_I_>

FIG.1A

User Data	Channel Bit
00	101
01	100
10	001
11	010

FIG.1B

User Data	Channel Bit
00.00	101.000
01.01	100.000
10.00	001.000
10.01	010.000

FIG. 2

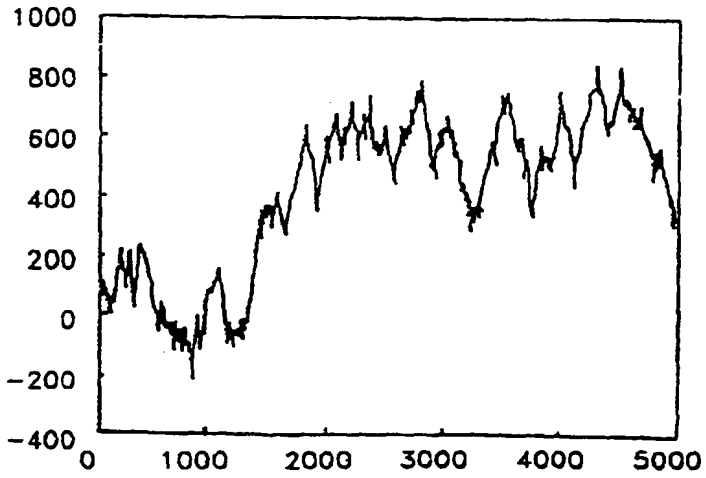


FIG. 3

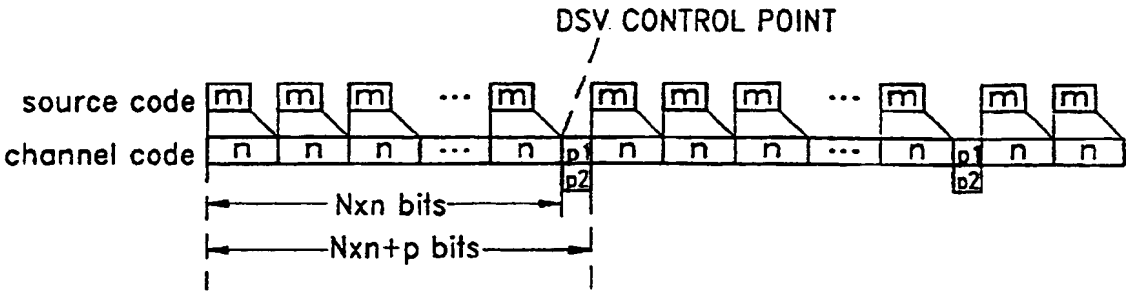


FIG. 4

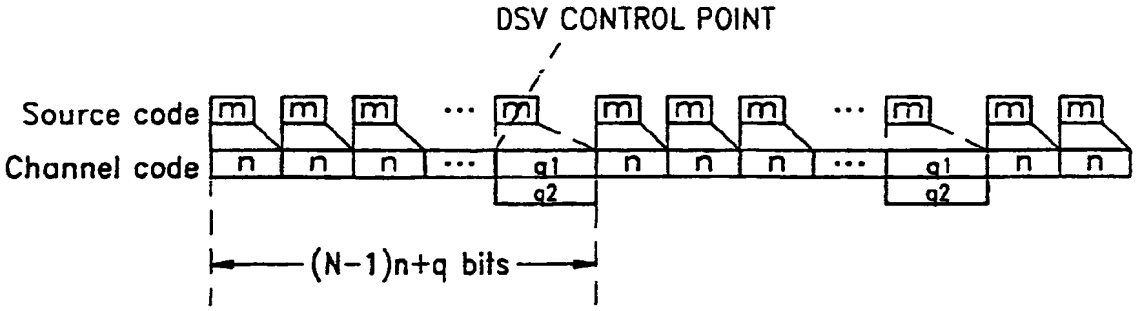
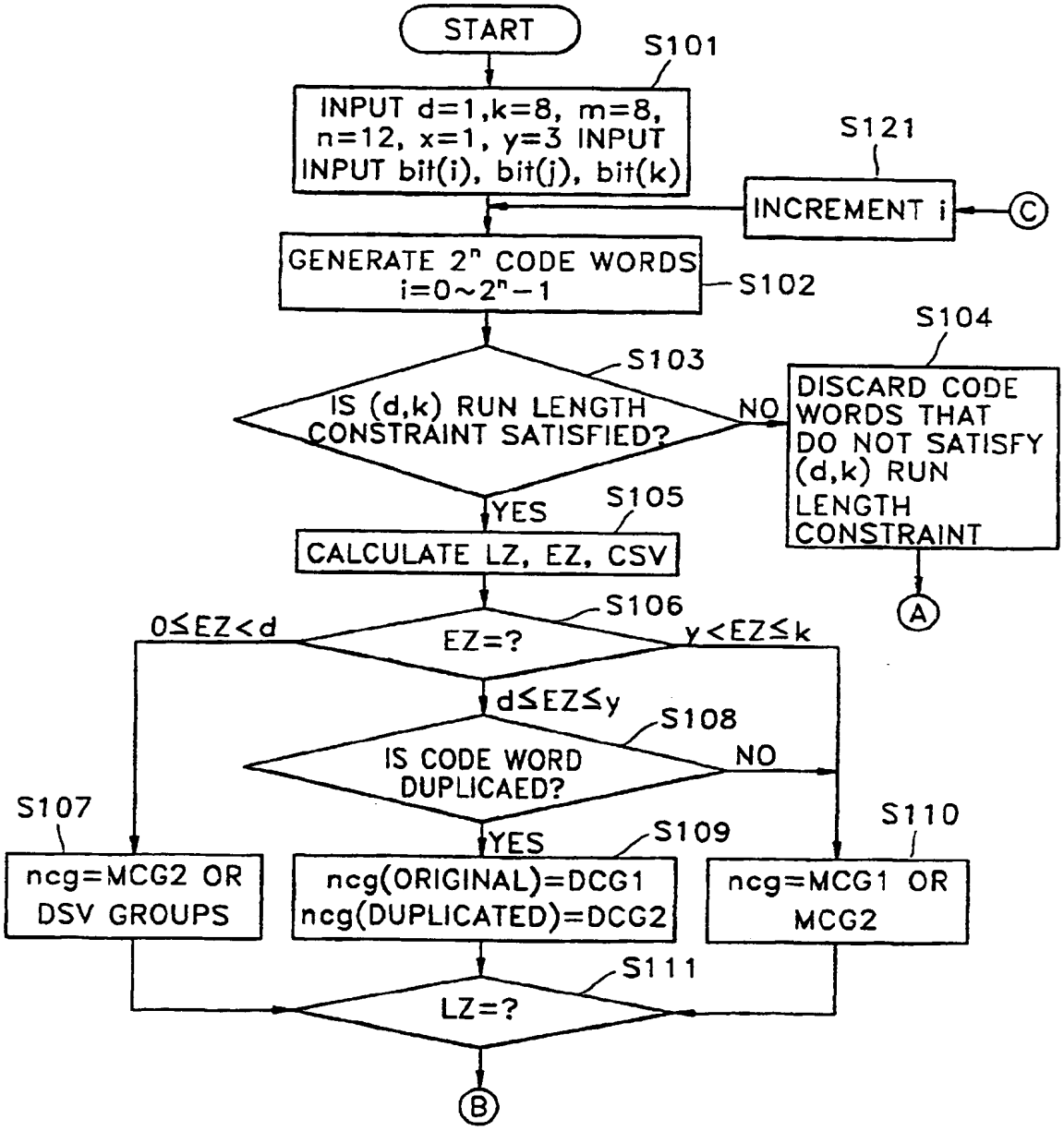


FIG. 5A



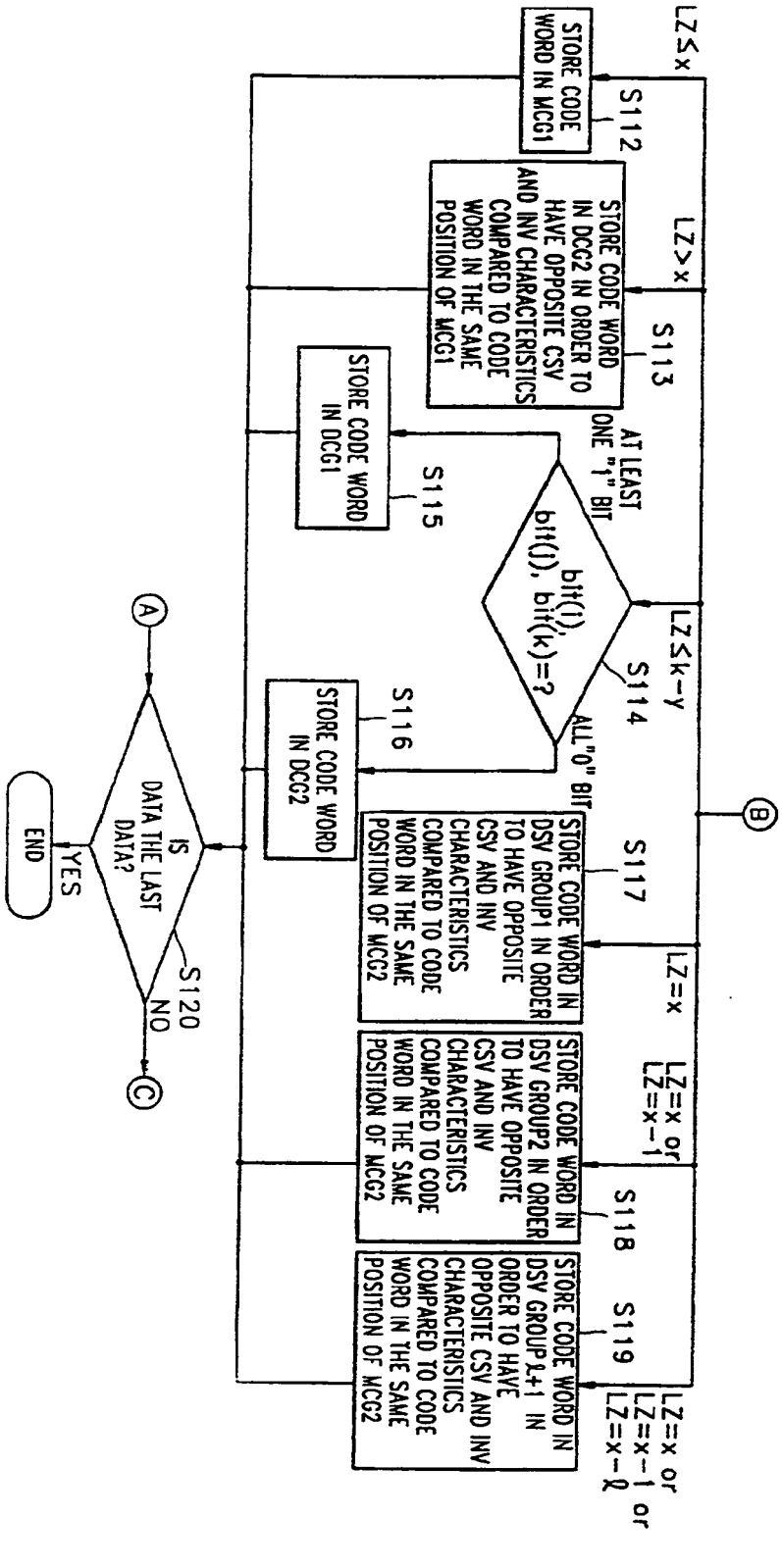


FIG. 5B

FIG. 6A

CODE GROUP	MCG1	MCG2	DCG1	DCG2	MCG1/MCG2	DSV CODE GROUP
CODE WORD CHARACTERISTIC	CODE WORD WHICH BEGINS WITH 10	CODE WORD WHICH BEGINS WITH 001~00000001	CODE WORD WHICH SATISFY LZ≤5 AND WHOSE BIT9 AND BIT5 ARE "1"	CODE WORD WHICH SATISFY LZ≤5 AND WHOSE BIT9 AND BIT5 ARE "0"	CODE WORD WHICH BEGINS WITH 01	CODE WORD WHICH BEGINS WITH 01 AND IS TO BE INCLUDED IN MCG1
THE NUMBER OF CODE WORDS	186	198	256	257	128	70

FIG. 6B

CODE GROUP	MCG1	MCG2	DCG1	DCG2	MCG1/MCG2	DSV CODE GROUP
CODE WORD CHARACTERISTIC	CODE WORD WHICH BEGINS WITH 10	CODE WORD WHICH BEGINS WITH 001~00000001	CODE WORD WHICH BEGINS WITH 10,00001 OR 000001	CODE WORD WHICH BEGIN WITH 01,001 OR 0001	CODE WORD WHICH BEGINS WITH 01	CODE WORD WHICH BEGINS WITH 010 AND IS TO BE INCLUDED IN MCG1
THE NUMBER OF CODE WORDS	186	198	256	257	128	70

FIG. 7A

Data Symbol	MCG1		MCG2		DCG1		DCG2	
	Code Word MSB LSB	Next Code Group	Code Word MSB LSB	Next Code Group	Code Word MSB LSB	Next Code Group	Code Word MSB LSB	Next Code Group
000	101010000000	1	001010000000	1	001010000000	1	010000000010	3
001	100101000000	1	000101000000	1	010000100101	2	000101000000	1
002	100010100000	1	000010100000	1	000010100000	1	010000000100	3
003	100001010000	1	000001010000	1	010000101001	2	000001010000	1
004	100000101000	3	000000101000	3	100000101000	3	010000000100	4
005	100000101000	4	000000101000	4	100000101000	4	010000001000	3
006	100000010100	3	000000010100	3	010000101010	3	100000010100	3
007	100000010100	4	000000010100	4	010010100010	3	100000010100	4
008	100000001010	1	001001000000	1	001001000000	1	100000001010	3
009	100000000101	2	000100100000	1	000100100000	1	100000000101	2
010	010101000000	1	000010010000	1	010010100010	4	000010010000	1
011	010010100000	1	000001001000	3	010010100000	1	000001001000	3
012	010001010000	1	000001001000	4	010010100101	2	000001001000	4
013	010000101000	3	000000100100	3	010000101000	3	010000010010	3
014	010000101000	4	000000100100	4	010000101000	4	010000010010	4
015	010000010100	3	000000010010	3	010010101010	3	010000010100	3
016	010000010100	4	000000010010	4	010010101010	4	010000010100	4
017	010000001010	3	010100010100	3	010100100000	1	010000001010	3
018	010000001010	4	010100010100	4	010100100001	2	010000001010	4
019	010000000101	2	010100001010	3	010100101000	3	010000000101	2
020	010000000010	3	001010000001	2	001010000001	2	010000000010	4
021	010000000010	4	000101000001	2	010100101000	4	000101000001	2
022	010010000000	1	001010100000	1	001010100000	1	010010000000	1
023	010100000001	2	001000000001	2	001000000001	2	010100000001	2
024	101010000001	2	000010100001	2	000010100001	2	010001001000	3
025	101001000000	1	010100001010	4	101001000000	1	010100001010	3
026	101000000001	2	001000000010	3	001000000010	3	010001001000	4
027	100101000001	2	000001010001	2	100000100010	3	000001010001	2
028	100100100000	1	010100000101	2	100100100000	1	010100000101	2
029	100010100001	2	000000101001	2	100010100001	2	010001010000	1
030	100010010000	1	010001000000	1	100000100100	3	010001000000	1
031	100001010001	2	000000010101	2	100000100100	4	100001010001	2
032	100001001000	3	001010101000	3	001010101000	3	100001001000	3
033	100001001000	4	001010101000	4	001010101000	4	100001001000	4
034	100000101001	2	010010000001	2	100000101001	2	010010000001	2
035	100000100100	3	001010010100	3	001010010100	3	010100000010	3
036	100000100100	4	001010010100	4	001010010100	4	010100001010	4
037	100000010101	2	001010000010	3	001010000010	3	100000010101	2
038	100000010010	1	001010001010	3	001010001010	3	100000010010	3
039	100000001001	2	001010001010	4	001010001010	4	100000001001	2
040	100000000100	3	001010000010	4	001010000010	4	100000000100	3
041	100000000100	4	001001000001	2	001001000001	2	100000000100	4
042	010101000001	2	000101000010	3	100000101010	3	000101000010	3
043	010100100000	1	001010000101	2	001010000101	2	010100010000	1
044	010010100001	2	000101000010	4	010010100001	2	000101000010	4
045	010010010000	1	001000100000	1	001000100000	1	010010010000	1
046	010001010001	2	000100100001	2	000100100001	2	010001010001	2
047	010001001000	3	000101010100	3	100010100000	1	000101010100	3
048	010001001000	4	000101010100	4	100010100010	3	000101010100	4
049	010000101001	2	000010100010	3	000010100010	3	010100010100	3
050	010000100100	3	000101001010	3	010000100100	3	000101001010	3
051	010000100100	4	000101001010	4	010000100100	4	000101001010	4
052	010000010101	2	000010100010	4	000010100010	4	010000010101	2
053	010000010010	3	000101000101	2	100010101010	3	000101000101	2
054	010000010010	4	000100010000	1	100010101010	4	000100010000	1
055	010000001001	2	000010101010	3	000010101010	3	010000001001	2
056	010000000100	3	000010010001	2	100100100010	3	000010010001	2
057	010000000100	4	000001010010	3	100100100101	2	000001010010	3
058	010100000010	3	001000000010	4	001000000010	4	010100000010	4
059	010100000010	4	000100010001	2	100100101001	2	000100000001	2
060	010100101000	3	001001010000	1	001001010000	1	010100010100	4

FIG. 7B

Data Symbol	MCG1 Code Word MSB LSB	MCG1 Next Code Group	MCG2 Code Word MSB LSB	MCG2 Next Code Group	DCG1 Code Word MSB LSB	DCG1 Next Code Group	DCG2 Code Word MSB LSB	DCG2 Next Code Group
061	010100101000	4	001000101000	3	001000101000	3	010101000000	1
062	010101010000	1	001000101000	4	001000101000	4	010101010000	1
063	101010101000	3	000010101010	4	000010101010	4	010101000001	2
064	101010101000	4	000010100101	2	000010100101	2	010101000010	3
065	101010100000	1	001000010100	3	001000010100	3	010101000010	4
066	101010010100	3	000010001000	3	101010010100	3	000010001000	3
067	101010010100	4	000010001000	4	101010010100	4	000010001000	4
068	101010001010	3	000001010101	2	101010001010	3	000001010101	2
069	101010001010	4	000001000100	3	101010001010	4	000001000100	3
070	101010000101	2	000001000100	4	101010000101	2	000001000100	4
071	101010000010	3	000001010010	4	101010000010	3	000001010010	4
072	101010000010	4	000001001001	2	101010000010	4	000001001001	2
073	101001010000	1	001000010100	4	001000010100	4	010101000101	2
074	101001000001	2	000000101010	3	101001000001	2	010101001010	3
075	101000101000	3	001000001010	3	001000001010	3	100000001000	3
076	101000101000	4	001000001010	4	001000001010	4	100000001000	4
077	101000100000	1	000000100010	3	101000100000	1	100000001010	4
078	101000010100	3	001000000101	2	001000000101	2	100000010001	2
079	101000010100	4	000010000000	1	101000010100	3	100000010010	4
080	101000001010	3	001010010000	1	001010010000	1	100001000001	2
081	101000001010	4	001001001000	3	001001001000	3	100001000010	3
082	101000000101	2	001001001000	4	001001001000	4	100001000010	4
083	101000000010	3	001010100001	2	001010100001	2	100001000100	3
084	101000000010	4	001001010001	2	001001010001	2	100001000101	2
085	100101010100	3	000000100010	4	100100101010	3	100101010100	3
086	100101010100	4	000000010001	2	100100101010	4	100101010100	4
087	100101001010	1	010101001000	3	101000000001	2	010101001000	3
088	100101000101	2	010101001000	4	101000000010	3	010101001000	4
089	100101000010	1	000000101010	4	101000000010	4	100101000010	3
090	100100100001	2	000000100101	2	100100100001	2	100001001001	2
091	100100010000	1	010100100100	3	010100100100	3	100100010000	1
092	100100000001	2	001000101001	2	001000101001	2	100100000001	2
093	100010101010	1	010100100100	4	010100100100	4	100001001010	3
094	100010100101	2	010100010010	3	100010100101	2	010100010010	3
095	100010100010	1	010101010001	2	100010100010	4	010101010001	2
096	100010010001	2	010100101001	2	010100101001	2	100010010001	2
097	100010001000	3	010100010010	4	101000000101	2	010100010010	4
098	100010001000	4	010100001001	2	101000001000	3	010100001001	2
099	100010000000	1	001000100100	3	001000100100	3	100010000000	1
100	100001010101	2	010010101000	3	010010101000	3	100001010101	2
101	100001010010	1	010100010101	2	101000001000	4	010100010101	2
102	100001001001	2	010100000100	3	101000001010	3	010100000100	3
103	100001000100	3	010010101000	4	010010101000	4	100001000100	4
104	100001000100	4	010010010100	3	101000010100	4	010010010100	3
105	100000101010	1	010100000100	4	100000101010	4	010100000100	4
106	100000100101	2	010010000010	3	100000100101	2	010010000010	3
107	100000100010	1	010010010100	4	100000100010	4	010010010100	4
108	100000010001	2	010010001010	3	101000010001	2	010010001010	3
109	100000001000	3	010010000010	4	101000010010	3	010010000010	4
110	100000001000	4	010001000001	2	101000010010	4	010001000001	2
111	010100100001	2	001010101001	2	001010101001	2	100001001010	4
112	010101000101	2	010010001010	4	101000010100	4	010010001010	4
113	010100010000	1	010010000101	2	101000100100	3	010010000101	2
114	010010100010	3	001010010101	2	001010010101	2	100001010000	1
115	010010100010	4	001010000100	3	001010000100	3	100001010010	3
116	010010100101	2	010000100000	1	010000100000	1	100001010010	4
117	010010010001	2	001010000100	4	001010000100	4	010010010001	2
118	010010001000	3	001010100100	3	001010100100	3	010010001000	3
119	010010001000	4	001010100100	4	001010100100	4	010010001000	4
120	010001010101	2	001010010010	3	001010010010	3	010001010101	2

FIG. 7C

Data Symbol	MCG1		MCG2		DCG1		DCG2	
	Code Word MSB LSB	Next Code Group	Code Word MSB LSB	Next Code Group	Code Word MSB LSB	Next Code Group	Code Word MSB LSB	Next Code Group
121	010001010010	3	001001000010	3	001001000010	3	010001010010	3
122	010001010010	4	001001000010	4	001001000010	4	010001010010	4
123	010001001001	2	001000100001	2	001000100001	2	010001001001	2
124	010001000100	3	001010010010	4	001010010010	4	010001000100	3
125	010001000100	4	001010001001	2	001010001001	2	010001000100	4
126	010000010001	2	001001010100	3	001001010100	3	010000010001	2
127	010101010100	3	001001010100	4	001001010100	4	010101010100	3
128	010101010100	4	001001001010	3	001001001010	3	010101010100	4
129	010101000010	3	000101010101	2	101000100101	2	000101010101	2
130	010101000010	4	000101000100	3	101000101000	3	000101000100	3
131	010010101010	3	001001001010	4	001001001010	4	100001010100	3
132	010010101010	4	001001000101	2	001001000101	2	100001010100	4
133	010101001010	3	001000010000	1	001000010000	1	010101001010	4
134	010101001010	4	000101010010	3	101000101000	4	000101010010	3
135	010000101010	3	000101000100	4	010000101010	4	000101000100	4
136	010000101010	4	000100100010	3	000100100010	3	100010000001	2
137	010000100101	2	000100100010	4	000100100010	4	100010000010	3
138	010000100010	3	000101010010	4	010000100010	3	000101010010	4
139	010000100010	4	000101001001	2	010000100010	4	000101001001	2
140	010000001000	3	000100010001	2	101000101001	2	000100010001	2
141	010000001000	4	000010100100	3	000010100100	3	010000001000	4
142	101010101001	2	000010100100	4	000010100100	4	100010000010	4
143	101010100100	3	000100101010	3	000100101010	3	100010000100	3
144	101010100100	4	000100101010	4	000100101010	4	100010000100	4
145	101010100001	2	001000010101	2	001000010101	2	100010001000	3
146	101010010101	2	000010010010	3	101010010101	2	000010010010	3
147	101010010010	3	000100100101	2	000100100101	2	100010001000	4
148	101010010010	4	000100001000	3	101010010010	3	000100001000	3
149	101010010000	1	001000100100	4	001000100100	4	100010001001	2
150	101010001001	2	000100001000	4	101010001001	2	000100001000	4
151	101010000100	3	000010010010	4	101010000100	3	000010010010	4
152	101010000100	4	000010001001	2	101010000100	4	000010001001	2
153	101001010100	3	000010101001	2	000010101001	2	100010001010	3
154	101001010100	4	000010010101	2	101001010100	3	000010010101	2
155	101001010001	2	001000000100	3	001000000100	3	100010001010	4
156	101001001010	3	000010000100	3	101001001010	3	000010000100	3
157	101001001010	4	000010000100	4	101001001010	4	000010000100	4
158	101001001000	3	001000010010	3	001000010010	3	100010010000	1
159	101001001000	4	001000010010	4	001000010010	4	100010010010	3
160	101001000101	2	000001000010	3	101001000101	2	000001000010	3
161	101001000010	3	000001010100	3	101001000010	3	000001010100	3
162	101001000010	4	000001010100	4	101001000010	4	000001010100	4
163	101000101001	2	001000000100	4	001000000100	4	100010010100	3
164	101000100100	3	001000001001	2	001000001001	2	100010010100	4
165	101000100100	4	000101010000	1	101000100100	4	000101010000	1
166	101000100001	2	000001001010	3	101000100001	2	000001001010	3
167	101000010101	2	000100000010	3	101000010101	2	000100000010	3
168	101000010010	3	000100101000	3	000100101000	3	100010010101	2
169	101000010010	4	000100101000	4	000100101000	4	100100000010	3
170	101000010000	1	000001000010	4	101000010000	1	000001000010	4
171	101000001001	2	000100010100	3	101000001001	2	000100010100	3
172	101000000100	3	000100000010	4	101000000100	3	000100000010	4
173	101000000100	4	000010000001	2	101000000100	4	000010000001	2
174	100101010101	2	000001001010	4	101000101010	3	000001001010	4
175	100101010010	1	000000100001	2	101000101010	4	100101010010	3
176	100101010000	1	000100010100	4	101001000100	3	000100010100	4
177	100101001001	2	010101010101	2	101001000100	4	010101010101	2
178	100101000100	3	000001000101	2	101001001000	3	000001000101	2
179	100101000100	4	000000010000	1	101001001000	4	100101000100	3
180	100100101010	1	010100100010	3	010100100010	3	100100000100	3

FIG. 7D

Data Symbol	MCG1		MCG2		DCG1		DCG2	
	Code Word MSB LSB	Next Code Group	Code Word MSB LSB	Next Code Group	Code Word MSB LSB	Next Code Group	Code Word MSB LSB	Next Code Group
181	100100101000	3	000100001010	3	100100101000	3	000100001010	3
182	100100101000	4	000100001010	4	100100101000	4	000100001010	4
183	100100100101	2	010100100010	4	010100100010	4	100100000100	4
184	100100100010	1	010101010010	3	100100100010	4	010101010010	3
185	100100010100	3	000100000101	2	101001001001	2	000100000101	2
186	100100010100	4	000001000000	1	101001010000	1	000001000000	1
187	100100010001	2	010101010010	4	101001010001	2	010101010010	4
188	100100001010	1	010101001001	2	101001010010	3	010101001001	2
189	100100001000	3	010100010001	2	101001010010	4	010100010001	2
190	100100001000	4	010010100100	3	010010100100	3	100100001000	3
191	100100000101	2	010100100101	2	010100100101	2	100100000101	2
192	100100000010	1	010010100100	4	010010100100	4	100100000010	4
193	100010101001	2	010010010010	3	100010101001	2	010010010010	3
194	100010100100	3	010100001000	3	100010100100	3	010100001000	3
195	100010100100	4	010100001000	4	100010100100	4	010100001000	4
196	100010010101	2	010010010010	4	101001010100	4	010010010010	4
197	100010010010	1	010010101001	2	010010101001	2	100010010010	4
198	100010001001	2	010010010101	2	101001010101	2	010010010101	2
199	100010000100	3	010010001001	2	101010000000	1	010010001001	2
200	100010000100	4	010001010100	3	101010000001	2	010001010100	3
201	100010000001	2	010001010100	4	101010001000	3	010001010100	4
202	100001010100	3	010010000100	3	101010001000	4	010010000100	3
203	100001010100	4	010010000100	4	101010010000	1	010010000100	4
204	100001001010	1	010001000010	3	101010010001	2	010001000010	3
205	100001000101	2	010001000010	4	101010010010	4	010001000010	4
206	100001000010	1	010001001010	3	101010100000	1	010001001010	3
207	100001000000	1	010000100001	2	010000100001	2	100001000000	1
208	100000100001	2	010001001010	4	100000100001	2	010001001010	4
209	100000010000	1	001010101010	3	001010101010	3	100000010000	1
210	010101000100	3	001010101010	4	001010101010	4	010101000100	3
211	010101000100	4	001010100101	2	001010100101	2	010101000100	4
212	010100101010	3	010001000101	2	010100101010	3	010001000101	2
213	010100101010	4	010000010000	1	010100101010	4	010000010000	1
214	101010101010	3	001010001000	3	001010001000	3	100100001000	4
215	101010101010	4	001010001000	4	001010001000	4	100100001010	3
216	101010100101	2	001001010101	2	001001010101	2	100100001010	4
217	101010100010	3	001010100010	3	001010100010	3	100100010001	2
218	101010100010	4	001010100010	4	001010100010	4	100100010010	3
219	101010010001	2	001010010001	2	001010010001	2	100100010100	3
220	101010001000	3	001001000100	3	001001000100	3	100100010100	4
221	101010001000	4	001001000100	4	001001000100	4	100100010101	2
222	101001010101	2	001000100010	3	001000100010	3	100101000000	1
223	101001010010	3	001001010010	3	001001010010	3	100101000001	2
224	101001010010	4	001001010010	4	001001010010	4	100101000010	4
225	101001001001	2	001001001001	2	001001001001	2	100101000100	4
226	101001000100	3	001000100010	4	001000100010	4	100101000101	2
227	101001000100	4	001000010001	2	001000010001	2	100101001000	3
228	101000101010	3	001000101010	3	001000101010	3	100101001001	2
229	101000101010	4	001000101010	4	001000101010	4	100101001010	3
230	101000100101	2	001000100101	2	001000100101	2	100101001010	4
231	101000100010	3	000101001000	3	101000100010	3	000101001000	3
232	101000100010	4	000101001000	4	101000100010	4	000101001000	4
233	101000010001	2	000100100100	3	000100100100	3	100101010000	1
234	101000001000	3	001000001000	3	001000001000	3	100101010001	2
235	101000001000	4	001000001000	4	001000001000	4	100101010010	4
236	100101010001	2	000101010001	2	101010100001	2	000101010001	2
237	100101001000	3	000100100100	4	000100100100	4	100101001000	4
238	100101001000	4	000100010010	3	101010100010	3	000100010010	3
239	100100101001	2	000100101001	2	000100101001	2	100101010101	2
240	100100100100	3	000100010010	4	100100100100	3	000100010010	4

FIG. 7E

Data Symbol	MCG1		MCG2		DCG1		DCG2	
	Code Word MSB LSB	Next Code Group	Code Word MSB LSB	Next Code Group	Code Word MSB LSB	Next Code Group	Code Word MSB LSB	Next Code Group
241	100100100100	4	000100001001	2	100100100100	4	000100001001	2
242	100100010101	2	000100010101	2	101010100010	4	000100010101	2
243	100100010010	1	000010101000	3	000010101000	3	100100010010	4
244	100100001001	2	000010101000	4	000010101000	4	100100001001	2
245	100100000100	3	000100000100	3	101010100100	3	000100000100	3
246	100100000100	4	000100000100	4	101010100100	4	000100000100	4
247	100010101000	3	000010010100	3	100010101000	3	000010010100	3
248	100010101000	4	000010010100	4	100010101000	4	000010010100	4
249	100010010100	3	000010001010	3	101010100101	2	000010001010	3
250	100010010100	4	000010001010	4	101010101000	3	000010001010	4
251	100010001010	1	000010000101	2	101010101000	4	000010000101	2
252	100010000101	2	000000100000	1	101010101001	2	100010000101	2
253	100010000010	1	000010000010	3	101010101010	3	000010000010	3
254	100001000001	2	000010000010	4	101010101010	4	000010000010	4
255	100000100000	1	000001000001	2	100000100000	1	000001000001	2

FIG. 8

Data Symbol	DSV Code Group		Data Symbol	DSV Code Group	
	Code Word MSB LSB	Next Code Group		Code Word MSB LSB	Next Code Group
000	010101000000	1	035	010001000100	3
001	010010100000	1	036	010001000100	4
002	010001010000	1	037	010000000100	3
003	010000101000	3	038	010000010001	2
004	010000101000	4	039	010101010100	3
005	010000010100	3	040	010000000100	4
006	010000010100	4	041	010100100001	2
007	010000001010	3	042	010010100010	3
008	010000001010	4	043	010101010100	4
009	010000000101	2	044	010010100010	4
010	010100100000	1	045	010010101010	3
011	010010010000	1	046	010010010001	2
012	010001001000	3	047	010010101010	4
013	010001001000	4	048	010101001010	3
014	010000100100	3	049	010001010010	3
015	010000100100	4	050	010101001010	4
016	010000010010	3	051	010000100010	3
017	010000010010	4	052	010001010010	4
018	010000001001	2	053	010000100010	4
019	010101000101	2	054	010100101010	3
020	010000000010	3	055	010100101010	4
021	010000000010	4	056	010001001001	2
022	010010000000	1	057	010101000010	3
023	010100000001	2	058	010100000010	4
024	010101000001	2	059	010100101000	3
025	010100010000	1	060	010100101000	4
026	010100000010	3	061	010101010000	1
027	010010100001	2	062	010101000010	4
028	010010100101	2	063	010000101010	3
029	010001010001	2	064	010000101010	4
030	010010001000	3	065	010000100101	2
031	010000101001	2	066	010000001000	3
032	010010001000	4	067	010000001000	4
033	010001010101	2	068	010101000100	3
034	010000010101	2	069	010101000100	4

FIG. 9A

Data Symbol	MCG1		MCG2		DCG1		DCG2	
	Code Word MSB LSB	Next Code Group	Code Word MSB LSB	Next Code Group	Code Word MSB LSB	Next Code Group	Code Word MSB LSB	Next Code Group
000	0101010000000	1	x001010000000	1	x001010000000	1	x010080000010	3
001	0100101000000	1	x000101000000	1	x010000100101	2	x000101000000	1
002	0100010100000	1	x000010100000	1	x000010100000	1	x010000000100	3
003	0100001010000	1	x000001010000	1	x010000101001	2	x000001010000	1
004	0100000101000	3	x000000101000	3	0100000101000	3	x010000000100	4
005	0100000101000	4	x000000101000	4	0100000101000	4	x010000001000	3
006	0100000010100	3	x000000010100	3	x010000101010	3	0100000010100	3
007	0100000010100	4	x000000010100	4	x010010100010	3	0100000010100	4
008	0100000001010	1	x001001000000	1	x001001000000	1	0100000001010	3
009	0100000000101	2	x000100100000	1	x000100100000	1	0100000000101	2
010	x010101000000	1	x000010010000	1	x010101000010	4	x000010010000	1
011	x010010100000	1	x000001001000	3	x010010100000	1	x000001001000	3
012	x010001010000	1	x000001001000	4	x010010100101	2	x000001001000	4
013	x010000101000	3	x000000100100	3	x010000101000	3	x010000010010	3
014	x010000101000	4	x000000100100	4	x010000101000	4	x010000010010	4
015	x010000010100	3	x000000010010	3	x010010101010	3	x010000010100	3
016	x010000010100	4	x000000010010	4	x010010101010	4	x010000010100	4
017	x010000001010	3	x010100010100	3	x010100100000	1	x010000001010	3
018	x010000001010	4	x010100010100	4	x010100100001	2	x010000001010	4
019	x010000000101	2	x010100001010	3	x010100101000	3	x010000000101	2
020	x010000000010	3	x001010000001	2	x001010000001	2	x010000000010	4
021	x010000000010	4	x000101000001	2	x010100101000	4	x000101000001	2
022	x010010000000	1	x001010100000	1	x001010100000	1	x010010000000	1
023	x010100000001	2	x001000000001	2	x001000000001	2	x010100000001	2
024	0101010000001	2	x000010100001	2	x000010100001	2	x010001001000	3
025	0101001000000	1	x010100001010	4	0101001000000	1	x010100001010	3
026	0101000000001	2	x001000000010	3	x001000000010	3	x010001001000	4
027	0100101000001	2	x000001010001	2	0100000100010	3	x000001010001	2
028	0100100100000	1	x010100000101	2	0100100100000	1	x010100000101	2
029	0100010100001	2	x000000101001	2	0100010100001	2	x010001010000	1
030	0100010010000	1	x010001000000	1	0100000100100	3	x010001000000	1
031	0100001010001	2	x000000010101	2	0100000100100	4	0100001010001	2
032	0100001001000	3	x001010101000	3	x001010101000	3	0100001001000	3
033	0100001001000	4	x001010101000	4	x001010101000	4	0100001001000	4
034	0100000101001	2	x010010000001	2	0100000101001	2	x010010000001	2
035	0100000100100	3	x001010010100	3	x001010010100	3	x010100000010	3
036	0100000100100	4	x001010010100	4	x001010010100	4	x010100001010	4
037	0100000010101	2	x001010000010	3	x001010000010	3	0100000010101	2
038	0100000010010	1	x001010001010	3	x001010001010	3	0100000010010	3
039	0100000001001	2	x001010001010	4	x001010001010	4	0100000001001	2
040	0100000000100	3	x001010000010	4	x001010000010	4	0100000000100	3
041	0100000000100	4	x001001000001	2	x001001000001	2	0100000000100	4
042	x010101000001	2	x000101000010	3	0100000101010	3	x000101000010	3
043	x010100100000	1	x001010000101	2	x001010000101	2	x010100010000	1
044	x010010100001	2	x000101000010	4	x010010100001	2	x000101000010	4
045	x010010010000	1	x001000100000	1	x001000100000	1	x010010010000	1
046	x010001010001	2	x000100100001	2	x000100100001	2	x010001010001	2
047	x010001001000	3	x000101010100	3	0100010100000	1	x000101010100	3
048	x010001001000	4	x000101010100	4	0100010100010	3	x000101010100	4
049	x010000101001	2	x000010100010	3	x000010100010	3	x010100010100	3
050	x010000100100	3	x000101001010	3	x010000100100	3	x000101001010	3
051	x010000100100	4	x000101001010	4	x010000100100	4	x000101001010	4
052	x010000010101	2	x000010100010	4	x000010100010	4	x010000010101	2
053	x010000010010	3	x000101000101	2	0100010101010	3	x000101000101	2
054	x010000010010	4	x000100010000	1	0100010101010	4	x000100010000	1
055	x010000001001	2	x000010101010	3	x000010101010	3	x010000001001	2
056	x010000000100	3	x000010010001	2	0100100100010	3	x000010010001	2
057	x010000000100	4	x000001010010	3	0100100100101	2	x000001010010	3
058	x010100000010	3	x001000000010	4	x001000000010	4	x010100000010	4
059	x010100000010	4	x000100000001	2	0100100101001	2	x000100000001	2
060	x010100101000	3	x001001010000	1	x001001010000	1	x010100010100	4

FIG. 9B

Data Symbol	MCG1		MCG2		DCG1		DCG2	
	Code Word MSB LSB	Next Code Group	Code Word MSB LSB	Next Code Group	Code Word MSB LSB	Next Code Group	Code Word MSB LSB	Next Code Group
061	x010100101000	4	x001000101000	3	x001000101000	3	x010101000000	1
062	x010101010000	1	x001000101000	4	x001000101000	4	x010101010000	1
063	0101010101000	3	x000010101010	4	x000010101010	4	x010101000001	2
064	0101010101000	4	x000010100101	2	x000010100101	2	x010101000010	3
065	0101010100000	1	x001000010100	3	x001000010100	3	x010101000010	4
066	0101010010100	3	x000010001000	3	0101010010100	3	x000010001000	3
067	0101010010100	4	x000010001000	4	0101010010100	4	x000010001000	4
068	0101010001010	3	x000001010101	2	0101010001010	3	x000001010101	2
069	0101010001010	4	x000001000100	3	0101010001010	4	x000001000100	3
070	0101010000101	2	x000001000100	4	0101010000101	2	x000001000100	4
071	0101010000010	3	x000001010010	4	0101010000010	3	x000001010010	4
072	0101010000010	4	x000001001001	2	0101010000010	4	x000001001001	2
073	0101001010000	1	x001000010100	4	x001000010100	4	x010101000101	2
074	0101001000001	2	x000000101010	3	0101001000001	2	x010101001010	3
075	0101000101000	3	x001000001010	3	x001000001010	3	0100000001000	3
076	0101000101000	4	x001000001010	4	x001000001010	4	0100000001000	4
077	0101000100000	1	x000000100010	3	0101000100000	1	0100000001010	4
078	0101000010100	3	x001000000101	2	x001000000101	2	0100000010001	2
079	0101000010100	4	x000010000000	1	0101000010100	3	0100000010010	4
080	0101000001010	3	x001010010000	1	x001010010000	1	0100001000001	2
081	0101000001010	4	x001001001000	3	x001001001000	3	0100001000010	3
082	0101000000101	2	x001001001000	4	x001001001000	4	0100001000010	4
083	0101000000010	3	x001010100001	2	x001010100001	2	0100001000100	3
084	0101000000010	4	x001001010001	2	x001001010001	2	0100001000101	2
085	0100101010100	3	x000000100010	4	0100100101010	3	0100101010100	3
086	0100101010100	4	x000000010001	2	0100100101010	4	0100101010100	4
087	0100101001010	1	x010101001000	3	0101000000001	2	x0101010 01000	3
088	0100101000101	2	x010101001000	4	0101000000010	3	x010101001000	4
089	0100101000010	1	x000000101010	4	0101000000010	4	0100101000010	3
090	0100100100001	2	x000000100101	2	0100100100001	2	0100001001001	2
091	0100100010000	1	x010100100100	3	x010100100100	3	0100100010000	1
092	0100100000001	2	x001000101001	2	x001000101001	2	0100100000001	2
093	0100010101010	1	x010100100100	4	x010100100100	4	0100001001010	3
094	0100010100101	2	x010100010010	3	0100010100101	2	x010100010010	3
095	0100010100010	1	x010101010001	2	0100010100010	4	x010101010001	2
096	0100010010001	2	x010100101001	2	x010100101001	2	0100010010001	2
097	0100010001000	3	x010100010010	4	0101000000101	2	x010100010010	4
098	0100010001000	4	x010100001001	2	0101000001000	3	x010100001001	2
099	0100010000000	1	x001000100100	3	x001000100100	3	0100010000000	1
100	0100001010101	2	x010010101000	3	x010010101000	3	0100001010101	2
101	0100001010010	1	x010100010101	2	0101000001000	4	x010100010101	2
102	0100001001001	2	x010100000100	3	0101000001010	3	x010100000100	3
103	0100001000100	3	x010010101000	4	x010010101000	4	0100001000100	4
104	0100001000100	4	x010010010100	3	0101000001010	4	x010010010100	3
105	0100000101010	1	x010100000100	4	0100000101010	4	x010100000100	4
106	0100000100101	2	x010010000010	3	0100000100101	2	x010010000010	3
107	0100000100010	1	x010010010100	4	0100000100010	4	x010010010100	4
108	0100000010001	2	x010010001010	3	0101000010001	2	x010010001010	3
109	0100000001000	3	x010010000010	4	0101000010010	3	x010010000010	4
110	0100000001000	4	x010001000001	2	0101000010010	4	x010001000001	2
111	x0101001000 01	2	x001010101001	2	x001010101001	2	0100001001010	4
112	x010101000101	2	x010010001010	4	0101000010100	4	x010010001010	4
113	x010100010000	1	x010010000101	2	0101000100100	3	x010010000101	2
114	x010010100010	3	x001010010101	2	x001010010101	2	0100001010000	1
115	x010010100010	4	x001010000100	3	x001010000100	3	0100001010010	3
116	x010010100101	2	x010000100000	1	x010000100000	1	0100001010010	4
117	x010010010001	2	x001010000100	4	x001010000100	4	x010010010001	2
118	x010010001000	3	x001010100100	3	x001010100100	3	x010010001000	3
119	x010010001000	4	x001010100100	4	x001010100100	4	x010010001000	4
120	x010001010101	2	x001010010010	3	x001010010010	3	x010001010101	2

FIG. 9C

Data Symbol	MCG1		MCG2		DCG1		DCG2	
	Code Word MSB LSB	Next Code Group	Code Word MSB LSB	Next Code Group	Code Word MSB LSB	Next Code Group	Code Word MSB LSB	Next Code Group
121	x010001010010	3	x001001000010	3	x001001000010	3	x010001010010	3
122	x010001010010	4	x001001000010	4	x001001000010	4	x010001010010	4
123	x010001001001	2	x001000100001	2	x001000100001	2	x010001001001	2
124	x010001000100	3	x001010010010	4	x001010010010	4	x010001000100	3
125	x010001000100	4	x001010001001	2	x001010001001	2	x010001000100	4
126	x010000010001	2	x001001010100	3	x001001010100	3	x010000010001	2
127	x010101010100	3	x001001010100	4	x001001010100	4	x010101010100	3
128	x010101010100	4	x001001001010	3	x001001001010	3	x010101010100	4
129	x010101000010	3	x000101010101	2	0101000100101	2	x000101010101	2
130	x010101000010	4	x000101000100	3	0101000101000	3	x000101000100	3
131	x010010101010	3	x001001001010	4	x001001001010	4	0100001010100	3
132	x010010101010	4	x001001000101	2	x001001000101	2	0100001010100	4
133	x010101001010	3	x001000010000	1	x001000010000	1	x010101001010	4
134	x010101001010	4	x000101010010	3	0101000101000	4	x000101010010	3
135	x010000101010	3	x000101000100	4	x010000101010	4	x000101000100	4
136	x010000101010	4	x000100100010	3	x000100100010	3	0100010000001	2
137	x010000100101	2	x000100100010	4	x000100100010	4	0100010000010	3
138	x010000100010	3	x000101010010	4	x010000100010	3	x000101010010	4
139	x010000100010	4	x000101001001	2	x010000100010	4	x000101001001	2
140	x010000001000	3	x000100010001	2	0101000101001	2	x000100010001	2
141	x010000001000	4	x000010100100	3	x000010100100	3	x010000001000	4
142	0101010101001	2	x000010100100	4	x000010100100	4	0100010000010	4
143	0101010100100	3	x000100101010	3	x000100101010	3	0100010000100	3
144	0101010100100	4	x000100101010	4	x000100101010	4	0100010000100	4
145	0101010100001	2	x001000010101	2	x001000010101	2	0100010001000	3
146	0101010010101	2	x000010010010	3	0101010010101	2	x000010010010	3
147	0101010010010	3	x000100100101	2	x000100100101	2	0100010001000	4
148	0101010010010	4	x000100001000	3	0101010010010	3	x000100001000	3
149	0101010010009	1	x001000100100	4	x001000100100	4	0100010001001	2
150	0101010001001	2	x000100001000	4	0101010001001	2	x000100001000	4
151	0101010000100	3	x000010010010	4	0101010000100	3	x000010010010	4
152	0101010000100	4	x000010001001	2	0101010000100	4	x000010001001	2
153	0101001010100	3	x000010101001	2	x000010101001	2	0100010001010	3
154	0101001010100	4	x000010010101	2	0101001010100	3	x000010010101	2
155	0101001010001	2	x001000000100	3	x001000000100	3	0100010001010	4
156	0101001001010	3	x000010000100	3	0101001001010	3	x000010000100	3
157	0101001001010	4	x000010000100	4	0101001001010	4	x000010000100	4
158	0101001001000	3	x001000010010	3	x001000010010	3	0100010010000	1
159	0101001001000	4	x001000010010	4	x001000010010	4	0100010010010	3
160	0101001000101	2	x000001000010	3	0101001000101	2	x000001000010	3
161	0101001000010	3	x000001010100	3	0101001000010	3	x000001010100	3
162	0101001000010	4	x000001010100	4	0101001000010	4	x000001010100	4
163	0101000101001	2	x001000000100	4	x001000000100	4	0100010010100	3
164	0101000100100	3	x001000001001	2	x001000001001	2	0100010010100	4
165	0101000100100	4	x000101010000	1	0101000100100	4	x000101010000	1
166	0101000100001	2	x000001001010	3	0101000100001	2	x000001001010	3
167	0101000010101	2	x000100000010	3	0101000010101	2	x000100000010	3
168	0101000010010	3	x000100101000	3	x000100101000	3	0100010010101	2
169	0101000010010	4	x000100101000	4	x000100101000	4	0100100000010	3
170	0101000010000	1	x000001000010	4	0101000010000	1	x000001000010	4
171	0101000001001	2	x000100010100	3	0101000001001	2	x000100010100	3
172	0101000000100	3	x000100000010	4	0101000000100	3	x000100000010	4
173	0101000000100	4	x000010000001	2	0101000000100	4	x000010000001	2
174	0100101010101	2	x000001001010	4	0101000101010	3	x000001001010	4
175	0100101010010	1	x000000100001	2	0101000101010	4	0100101010010	3
176	0100101010000	1	x000100010100	4	0101001001010	3	x000100010100	4
177	0100101001001	2	x010101010101	2	0101001001010	4	x010101010101	2
178	0100101000100	3	x000001000101	2	0101001001000	3	x000001000101	2
179	0100101000100	4	x000000010000	1	0101001001000	4	0100101000100	3
180	0100100101010	1	x010100100010	3	0101001000010	3	0100100000100	3

FIG. 9D

Data Symbol	NCG1 Code Word MSB LSB	NCG1 Next Code Group	NCG2 Code Word MSB LSB	NCG2 Next Code Group	DCG1 Code Word MSB LSB	DCG1 Next Code Group	DCG2 Code Word MSB LSB	DCG2 Next Code Group
181	0100100101000	3	x000100001010	3	0100100101000	3	x000100001010	3
182	0100100101000	4	x000100001010	4	0100100101000	4	x000100001010	4
183	0100100100101	2	x010100100010	4	x010100100010	4	0100100000100	4
184	0100100100010	1	x010101010010	3	0100100100010	4	x010101010010	3
185	0100100010100	3	x000100000101	2	0101001001001	2	x000100000101	2
186	0100100010100	4	x000001000000	1	0101001010000	1	x000001000000	1
187	0100100010001	2	x010101010010	4	0101001010001	2	x010101010010	4
188	0100100001010	1	x010101001001	2	0101001010010	3	x010101001001	2
189	0100100001000	3	x010100010001	2	0101001010010	4	x010100010001	2
190	0100100001000	4	x010010100100	3	x010010100100	3	0100100001000	3
191	0100100000101	2	x010100100101	2	x010100100101	2	0100100000101	2
192	0100100000010	1	x010010100100	4	x010010100100	4	0100100000010	4
193	0100010101001	2	x010010010010	3	0100010101001	2	x010010010010	3
194	0100010100100	3	x010100001000	3	0100010100100	3	x010100001000	3
195	0100010100100	4	x010100001000	4	0100010100100	4	x010100001000	4
196	0100010010101	2	x010010010010	4	0101001010100	4	x010010010010	4
197	0100010010010	1	x010010101001	2	x010010101001	2	0100010010010	4
198	0100010001001	2	x010010010101	2	0101001010101	2	x010010010101	2
199	0100010000100	3	x010010001001	2	0101010000000	1	x010010001001	2
200	0100010000100	4	x010001010100	3	0101010000001	2	x010001010100	3
201	0100010000001	2	x010001010100	4	0101010001000	3	x010001010100	4
202	0100001010100	3	x010010000100	3	0101010001000	4	x010010000100	3
203	0100001010100	4	x010010000100	4	0101010010000	1	x010010000100	4
204	0100001001010	1	x010001000010	3	0101010010001	2	x010001000010	3
205	0100001000101	2	x010001000010	4	0101010010010	4	x010001000010	4
206	0100001000010	1	x010001001010	3	0101010100000	1	x010001001010	3
207	0100001000000	1	x010000100001	2	x010000100001	2	0100001000000	1
208	0100000100001	2	x010001001010	4	0100000100001	2	x010001001010	4
209	0100000010000	1	x001010101010	3	x001010101010	3	0100000010000	1
210	x010101000100	3	x001010101010	4	x001010101010	4	x010101000100	3
211	x010101000100	4	x001010100101	2	x001010100101	2	x010101000100	4
212	x010100101010	3	x010001000101	2	x010100101010	3	x010001000101	2
213	x010100101010	4	x010000010000	1	x010100101010	4	x010000010000	1
214	0101010101010	3	x001010001000	3	x001010001000	3	0100100001000	4
215	0101010101010	4	x001010001000	4	x001010001000	4	0100100001010	3
216	0101010100101	2	x001001010101	2	x001001010101	2	0100100001010	4
217	0101010100010	3	x001010100010	3	x001010100010	3	0100100010001	2
218	0101010100010	4	x001010100010	4	x001010100010	4	0100100010010	3
219	0101010010001	2	x001010010001	2	x001010010001	2	0100100010100	3
220	0101010001000	3	x001001000100	3	x001001000100	3	0100100010100	4
221	0101010001000	4	x001001000100	4	x001001000100	4	0100100010101	2
222	0101001010101	2	x001000100010	3	x001000100010	3	0100101000000	1
223	0101001010010	3	x001001010010	3	x001001010010	3	0100101000001	2
224	0101001010010	4	x001001010010	4	x001001010010	4	0100101000010	4
225	0101001001001	2	x001001001001	2	x001001001001	2	0100101000100	4
226	0101001000100	3	x001000100010	4	x001000100010	4	0100101000101	2
227	0101001000100	4	x001000010001	2	x001000010001	2	0100101001000	3
228	0101000101010	3	x001000101010	3	x001000101010	3	0100101001001	2
229	0101000101010	4	x001000101010	4	x001000101010	4	0100101001010	3
230	0101000100101	2	x001000100101	2	x001000100101	2	0100101001010	4
231	0101000100010	3	x000101001000	3	0101000100010	3	x000101001000	3
232	0101000100010	4	x000101001000	4	0101000100010	4	x000101001000	4
233	0101000010001	2	x000100100100	3	x000100100100	3	0100101010000	1
234	0101000001000	3	x001000001000	3	x001000001000	3	0100101010001	2
235	0101000001000	4	x001000001000	4	x001000001000	4	0100101010010	4
236	0100101010001	2	x000101010001	2	0101010100001	2	x000101010001	2
237	0100101001000	3	x000100100100	4	x000100100100	4	0100101001000	4
238	0100101001000	4	x000100010010	3	0101010100010	3	x000100010010	3
239	0100100101001	2	x000100101001	2	x000100101001	2	0100101010101	2
240	0100100100100	3	x000100010010	4	0100100100100	3	x000100010010	4

FIG. 9E

Data Symbol	MCG1		MCG2		DCG1		DCG2	
	Code Word MSB LSB	Next Code Group	Code Word MSB LSB	Next Code Group	Code Word MSB LSB	Next Code Group	Code Word MSB LSB	Next Code Group
241	0100100100100	4	x000100001001	2	0100100100100	4	x000100001001	2
242	0100100010101	2	x000100010101	2	0101010100010	4	x000100010101	2
243	0100100010010	1	x000010101000	3	x000010101000	3	0100100010010	4
244	0100100001001	2	x000010101000	4	x000010101000	4	0100100001001	2
245	0100100000100	3	x000100000100	3	0101010100100	3	x000100000100	3
246	0100100000100	4	x000100000100	4	0101010100100	4	x000100000100	4
247	0100010101000	3	x000010010100	3	0100010101000	3	x000010010100	3
248	0100010101000	4	x000010010100	4	0100010101000	4	x000010010100	4
249	0100010010100	3	x000010001010	3	0101010100101	2	x000010001010	3
250	0100010010100	4	x000010001010	4	0101010101000	3	x000010001010	4
251	0100010001010	1	x000010000101	2	0101010101000	4	x000010000101	2
252	0100010000101	2	x000000100000	1	0101010101001	2	0100010000101	2
253	0100010000010	1	x000010000010	3	0101010101010	3	x000010000010	3
254	0100001000001	2	x000010000010	4	0101010101010	4	x000010000010	4
255	0100000100000	1	x000001000001	2	0100000100000	1	x000001000001	2

FIG. 10

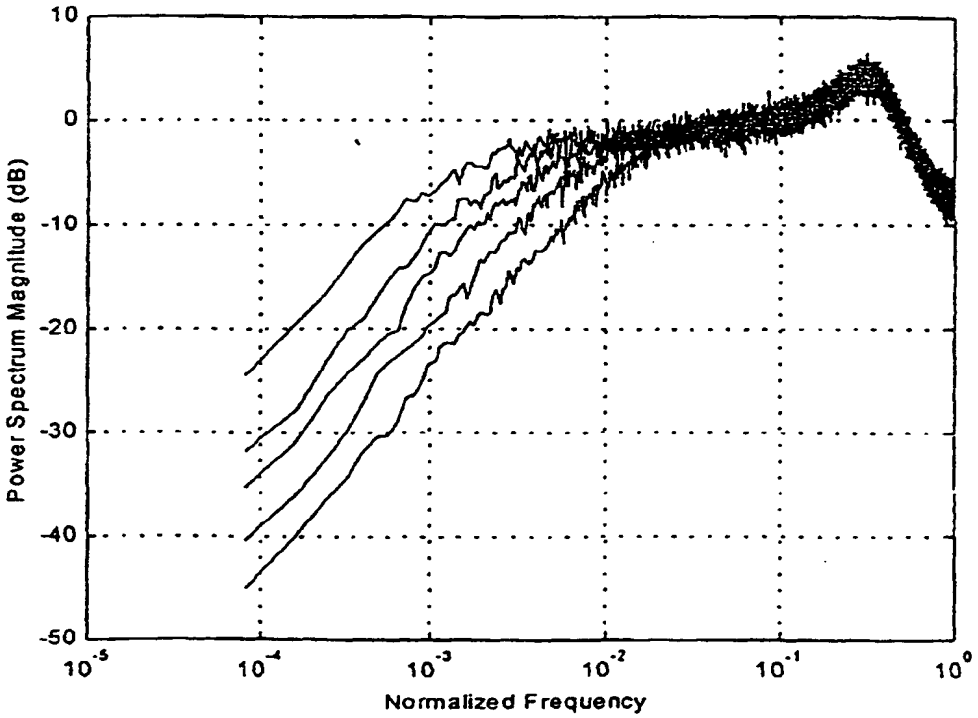


FIG. 11

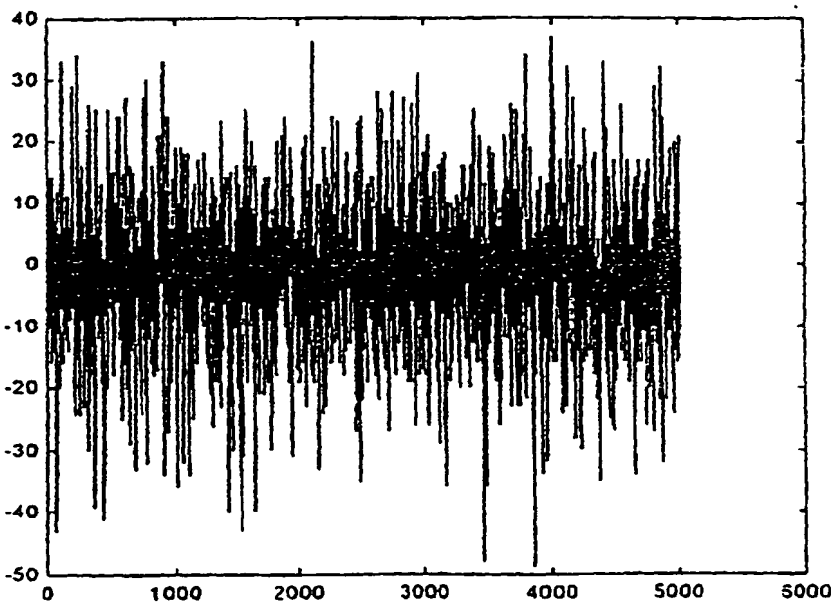


FIG. 12A

No	MCG1-1	Ncg 1-1	MCG2-1	Ncg 2-1	DCG1-1	Ncg 3-1	DCG2-1	Ncg 4-1
0	1000010100000000	1	0100010100000000	1	1000010100000000	1	0100010100000000	1
1	1000010100000000	1	0100010100000000	1	1000010100000000	1	0100010100000000	1
2	1000000101000000	1	0100000101000000	1	1000000101000000	1	0100000101000000	1
3	1000000101000000	1	0100000101000000	1	1000000101000000	1	0100000101000000	1
4	1000000001010000	3	0100000001010000	3	1000000001010000	3	0100000001010000	3
5	1000000001010000	4	0100000001010000	4	1000000001010000	4	0100000001010000	4
6	1000000000101000	3	0100000000101000	3	1000000000101000	3	0100000000101000	3
7	1000000000101000	4	0100000000101000	4	1000000000101000	4	0100000000101000	4
8	1010101000000001	2	0100000000101010	3	1010101000000001	2	0100000000101010	3
9	1001010000000001	2	0100000000101010	4	1001010000000001	2	0100000000101010	4
10	1001001000000000	1	0101010000000001	2	1001001000000000	1	0101010000000001	2
11	1000101000000001	2	0101001000000000	1	1000101000000001	2	0101001000000000	1
12	1000100100000000	1	0100101000000001	2	1000100100000000	1	0100101000000001	2
13	1000001010000001	2	0100010010000000	1	1000001010000001	2	0100010010000000	1
14	1000001001000000	1	0100001010000001	2	1000001001000000	1	0100001010000001	2
15	1000001010000001	2	0100001001000000	1	1000001010000001	2	0100001001000000	1
16	1000001001000000	1	0100001010000001	2	1000001001000000	1	0100001010000001	2
17	1000000101000001	2	0100000100100000	1	1000000101000001	2	0100000100100000	1
18	1000000100100000	3	0100000101000001	2	1000000100100000	3	0100000101000001	2
19	1000000100100000	4	0100000100100000	3	1000000100100000	4	0100000100100000	3
20	1000000001010001	2	0100000100100000	4	1000000001010001	2	0100000100100000	4
21	1000000001001000	3	0100000001010001	2	1000000001001000	3	0100000001010001	2
22	1000000001001000	4	0100000001001000	3	1000000001001000	4	0100000001001000	3
23	1000000000101010	2	0100000001001000	4	1000000000101010	2	0100000001001000	4
24	1000000000100100	3	0100000000101010	2	1000000000100100	3	0100000000101010	2
25	1000000000100100	4	0100000000100100	3	1000000000100100	4	0100000000100100	3
26	1010101010000000	1	0100000000100100	4	1010101010000000	1	0100000000100100	4
27	1010100010100000	1	0100000000101010	2	1010100010100000	1	0100000000101010	2
28	1010100001010000	3	0001010100000000	1	1010100001010000	3	0001010100000000	1
29	1010100001010000	4	0001001010000000	1	1010100001010000	4	0001001010000000	1
30	1010100000101000	3	0001000101000000	1	1010100000101000	3	0001000101000000	1
31	1010100000101000	4	0001000101000000	1	1010100000101000	4	0001000101000000	1
32	1010100000001010	3	0001000001010000	3	1010100000001010	3	0001000001010000	3
33	1010100000001010	4	0001000001010000	4	1010100000001010	4	0001000001010000	4
34	1010100000000101	2	0001000000101000	3	1010100000000101	2	0001000000101000	3
35	1010100000000010	3	0001000000101000	4	1010100000000010	3	0001000000101000	4
36	1010100000000010	4	0001000000001010	3	1010100000000010	4	0001000000001010	3
37	1010010000000001	2	0001000000001010	4	1010010000000001	2	0001000000001010	4
38	1010001000000000	1	0001000000000101	2	1010001000000000	1	0001000000000101	2
39	1001010101010000	1	0101010101010000	1	1001010101010000	1	0101010101010000	1
40	1001010010101000	3	0101010010101000	3	1001010010101000	3	0101010010101000	3
41	1001010010101000	4	0101010010101000	4	1001010010101000	4	0101010010101000	4
42	1001010000101000	3	0101010000101000	3	1001010000101000	3	0101010000101000	3
43	1001010000101000	4	0101010000101000	4	1001010000101000	4	0101010000101000	4
44	1001010000001010	3	0101010000001010	3	1001010000001010	3	0101010000001010	3
45	1001010000001010	4	0101010000001010	4	1001010000001010	4	0101010000001010	4
46	1001010000000101	2	0101010000000101	2	1001010000000101	2	0101010000000101	2
47	1001010000000010	3	0101010000000010	3	1001010000000010	3	0101010000000010	3
48	1001010000000010	4	0101010000000010	4	1001010000000010	4	0101010000000010	4
49	1001001000000001	2	0101001000000001	2	1001001000000001	2	0101001000000001	2
50	1001000100000000	1	0101000100000000	1	1001000100000000	1	0101000100000000	1
51	1000101010101000	3	0100101010101000	3	1000101010101000	3	0100101010101000	3
52	1000101010101000	4	0100101010101000	4	1000101010101000	4	0100101010101000	4
53	1000101000101000	3	0100101000101000	3	1000101000101000	3	0100101000101000	3
54	1000101000101000	4	0100101000101000	4	1000101000101000	4	0100101000101000	4
55	1000101000001010	3	0100101000001010	3	1000101000001010	3	0100101000001010	3
56	1000101000001010	4	0100101000001010	4	1000101000001010	4	0100101000001010	4
57	1000101000000101	2	0100101000000101	2	1000101000000101	2	0100101000000101	2
58	1000101000000010	3	0100101000000010	3	1000101000000010	3	0100101000000010	3
59	1000101000000010	4	0100101000000010	4	1000101000000010	4	0100101000000010	4
60	1000100100000001	2	0100100100000001	2	1000100100000001	2	0100100100000001	2
61	1000100010000000	1	0100100010000000	1	1000100010000000	1	0100100010000000	1
62	1000001010101000	3	0100001010101000	3	1000001010101000	3	0100001010101000	3
63	1000001010101000	4	0100001010101000	4	1000001010101000	4	0100001010101000	4
64	1000001010001010	3	0100001010001010	3	1000001010001010	3	0100001010001010	3
65	1000001010001010	4	0100001010001010	4	1000001010001010	4	0100001010001010	4
66	1000001010000101	2	0100001010000101	2	1000001010000101	2	0100001010000101	2
67	1000001010000010	3	0100001010000010	3	1000001010000010	3	0100001010000010	3
68	1000001010000010	4	0100001010000010	4	1000001010000010	4	0100001010000010	4
69	1000001001000001	2	0100001001000001	2	1000001001000001	2	0100001001000001	2
70	1000001000100000	1	0100001000100000	1	1000001000100000	1	0100001000100000	1
71	1000000101010010	3	0100000101010010	3	1000000101010010	3	0100000101010010	3
72	1000000101010010	4	0100000101010010	4	1000000101010010	4	0100000101010010	4
73	1000000101001010	2	0100000101001010	2	1000000101001010	2	0100000101001010	2
74	1000000101000010	3	0100000101000010	3	1000000101000010	3	0100000101000010	3
75	1000000101000010	4	0100000101000010	4	1000000101000010	4	0100000101000010	4
76	1000000100100001	2	0100000100100001	2	1000000100100001	2	0100000100100001	2
77	1000000100001000	3	0100000100001000	3	1000000100001000	3	0100000100001000	3
78	1000000100001000	4	0100000100001000	4	1000000100001000	4	0100000100001000	4
79	1000000010101010	2	0100000010101010	2	1000000010101010	2	0100000010101010	2
80	1000000010100010	3	0100000010100010	3	1000000010100010	3	0100000010100010	3
81	1000000010100010	4	0100000010100010	4	1000000010100010	4	0100000010100010	4
82	1000000010001001	2	0100000010001001	2	1000000010001001	2	0100000010001001	2
83	1000000010000100	3	0100000010000100	3	1000000010000100	3	0100000010000100	3
84	1000000010000100	4	0100000010000100	4	1000000010000100	4	0100000010000100	4
85	1000000001010010	3	0100000001010010	3	1000000001010010	3	0100000001010010	3
86	1000000001010010	4	0100000001010010	4	1000000001010010	4	0100000001010010	4
87	1000000000100101	2	0100000000100101	2	1000000000100101	2	0100000000100101	2
88	1000000000100010	3	0100000000100010	3	1000000000100010	3	0100000000100010	3
89	1000000000100010	4	0100000000100010	4	1000000000100010	4	0100000000100010	4

FIG. 12B

No	MCG1-1	Ncg 1-1	MCG2-1	Ncg 2-1	DCG1-1	Ncg 3-1	DCG2-1	Ncg 4-1
90	10000000010001	2	01000000010001	2	10000000010001	2	01000000010001	2
91	10101010100001	2	01000000001000	3	10101010100001	2	01000000001000	3
92	10101010010000	1	01000000001000	4	10101010010000	1	01000000001000	4
93	10101001010001	2	00101010000001	2	10101001010001	2	00101010000001	2
94	10101001001000	3	00101001000000	1	10101001001000	3	00101001000000	1
95	10101001001000	4	00100101000001	2	10101001001000	4	00100101000001	2
96	10101000101001	2	00100100100000	1	10101000101001	2	00100100100000	1
97	10101000100100	3	00100010100001	2	10101000100100	3	00100010100001	2
98	10101000100100	4	00100010010000	1	10101000100100	4	00100010010000	1
99	10101000010101	2	00100001010001	2	10101000010101	2	00100001010001	2
100	10101000010010	3	00100001001000	3	10101000010010	3	00100001001000	3
101	10101000010010	4	00100001001000	4	10101000010010	4	00100001001000	4
102	10101000001001	2	00100000101001	2	10101000001001	2	00100000101001	2
103	10101000000100	3	00100000100100	3	10101000000100	3	00100000100100	3
104	10101000000100	4	00100000100100	4	10101000000100	4	00100000100100	4
105	10100101010000	1	00100000010101	2	10100101010000	1	00100000010101	2
106	10100100101000	3	00100000010010	3	10100100101000	3	00100000010010	3
107	10100100101000	4	00100000010010	4	10100100101000	4	00100000010010	4
108	10100100010100	3	00100000001001	2	10100100010100	3	00100000001001	2
109	10100100010100	4	00100000000100	3	10100100010100	4	00100000000100	3
110	10100100001010	3	00100000000100	4	10100100001010	3	00100000000100	4
111	10100100001010	4	00010101000000	1	10100100001010	4	00010101000000	1
112	10100100000101	2	00010010100000	1	10100100000101	2	00010010100000	1
113	10100100000010	3	00010001010000	1	10100100000010	3	00010001010000	1
114	10100100000010	4	00010000101000	3	10100100000010	4	00010000101000	3
115	10100010000001	2	00010000101000	4	10100010000001	2	00010000101000	4
116	10100001000000	1	00010000010100	3	10100001000000	1	00010000010100	3
117	10010101010001	2	00010000010100	4	10010101010001	2	00010000010100	4
118	10010101001000	3	00010000000101	2	10010101001000	3	00010000001010	3
119	10010101001000	4	00010000000010	3	10010101001000	4	00010000001010	4
120	10010100101001	2	00010000000010	4	10010100101001	2	00010000000101	2
121	10010100100100	3	00001000000001	2	10010100100100	3	00010000000010	3
122	10010100100100	4	01010101010001	2	10010100100100	4	00010000000010	4
123	10010100010101	2	01010101001000	3	10010100010101	2	01010101010001	2
124	10010100010010	3	01010101001000	4	10010100010010	3	01010101001000	3
125	10010100010010	4	01010100101001	2	10010100010010	4	01010101001000	4
126	10010100001001	2	01010100100100	3	10010100001001	2	01010100101001	2
127	10010100000100	3	01010100100100	4	10010100000100	3	01010100100100	3
128	10010100000100	4	01010100010101	2	10010100000100	4	01010100100100	4
129	10010010101000	3	01010100010010	3	10010010101000	3	01010100010101	2
130	10010010101000	4	01010100010010	4	10010010101000	4	01010100010010	3
131	10010010010100	3	01010100001001	2	10010010010100	3	01010100010010	4
132	10010010010100	4	01010100000100	3	10010010010100	4	01010100001001	2
133	10010010001010	3	01010100000100	4	10010010001010	3	01010100000100	3
134	10010010001010	4	01010010101000	3	10010010001010	4	01010100000100	4
135	10010010000101	2	01010010101000	4	10010010000101	2	01010010101000	3
136	10010010000010	3	01010010010100	3	10010010000010	3	01010010101000	4
137	10010010000010	4	01010010010100	4	10010010000010	4	01010010010100	3
138	10010001000001	2	01010010001010	3	10010001000001	2	01010010010100	4
139	10010000100000	1	01010010001010	4	10010000100000	1	01010010001010	3
140	10001010101001	2	01010010000101	2	10001010101001	2	01010010001010	4
141	10001010100100	3	01010010000010	3	10001010100100	3	01010010000101	2
142	10001010100100	4	01010010000010	4	10001010100100	4	01010010000010	3
143	10001010010101	2	01010001000001	2	10001010010101	2	01010010000010	4
144	10001010010010	3	01010000100000	1	10001010010010	3	01010001000001	2
145	10001010010010	4	01001010101001	2	10001010010010	4	01010000100000	1
146	10001010001001	2	01001010100100	3	10001010001001	2	01001010101001	2
147	10001010000100	3	01001010100100	4	10001010000100	3	01001010100100	3
148	10001010000100	4	01001010010101	2	10001010000100	4	01001010100100	4
149	10001001010100	3	01001010010010	3	10001001010100	3	01001010010101	2
150	10001001010100	4	01001010010010	4	10001001000101	2	01001010010010	3
151	10001001001010	3	01001010001001	2	10001001000010	3	01001010010010	4
152	10001001001010	4	01001010000100	3	10001001000010	4	01001010001001	2
153	10001001000101	2	01001010000100	4	10001000100001	2	01001010000100	3
154	10001001000010	3	01001001010100	3	10001000010000	1	01001010000100	4
155	10001001000010	4	01001001010100	4	10000101010101	2	01001001010100	3
156	10001000100001	2	01001001001010	3	10000101001001	2	01001001010100	4
157	10001000010000	1	01001001001010	4	10000101000100	3	01001001001010	3
158	10000101010101	2	01001001000101	2	10000101000100	4	01001001001010	4
159	10000101010010	3	01001001000010	3	10000100100101	2	01001001000101	2
160	10000101010010	4	01001001000010	4	10000100100010	3	01001001000010	3
161	10000101001001	2	01001000100001	2	10000100100010	4	01001001000010	4
162	10000101000100	3	01001000010000	1	10000100010001	2	01001000100001	2
163	10000101000100	4	01000101010101	2	10000010101001	2	01001000010000	1
164	10000100101010	3	01000101010010	3	10000010100100	3	01000101010101	2
165	10000100101010	4	01000101010010	4	10000010100100	4	01000101010010	3
166	10000100100101	2	01000101001001	2	10000010010101	2	01000101010010	4
167	10000100100010	3	01000101000100	3	10000010010010	3	01000101001001	2
168	10000100100010	4	01000101000100	4	10000010010010	4	01000101000100	3
169	10000100010001	2	01000100101010	3	10000010001001	2	01000101000100	4
170	10000100001000	3	01000100101010	4	10000001010100	3	01000100101010	3
171	10000100001000	4	01000100100101	2	10000001010100	4	01000100101010	4
172	10000010101001	2	01000100100010	3	10000001001010	3	01000100100101	2
173	10000010100100	3	01000100100010	4	10000001001010	4	01000100100010	3
174	10000010100100	4	01000100010001	2	10000001000101	2	01000100100010	4
175	10000010010101	2	01000100001000	3	10000000100001	2	01000100010001	2
176	10000010010010	3	01000100001000	4	10000000010000	1	01000100001000	3
177	10000010010010	4	01000010101001	2	00001000000001	2	01000100001000	4
178	10000010001001	2	01000010100100	3	10101010100101	2	01000010101001	2
179	10000010000100	3	01000010100100	4	10101010100010	3	01000010100100	3

FIG. 12C

No	MCG1-1	Ncg 1-1	MCG2-1	Ncg 2-1	DCG1-1	Ncg 3-1	DCG2-1	Ncg 4-1
180	1000001000100	4	0100001001010	2	1010101010010	4	0100001010010	4
181	1000000101010	3	0100001001010	3	1010101001001	2	0100001001010	2
182	1000000101010	4	0100001001010	4	1010100101010	2	0100001001010	3
183	1000000100101	3	0100001000100	2	1010100101001	3	0100001001010	4
184	1000000100101	4	0100001000010	3	1010100101001	4	0100001000100	2
185	1000000100010	2	0100001000100	4	1010100100100	2	0100001000100	3
186	1000000100010	3	0100000101010	3	1010100010101	3	0100001000100	4
187	1000000100010	4	0100000101010	4	1010100010101	4	0100000101010	3
188	1000000010001	2	0100000100101	3	1010100010010	2	0100000101010	4
189	1000000001000	1	0100000100101	4	1010100001001	2	0100000100101	3
190	1010101010101	2	0100000100010	2	1010100000100	3	0100000100101	4
191	1010101010010	3	0100000100010	3	1010100000100	4	0100000100010	2
192	1010101010010	4	0100000100010	4	1010010101001	2	0100000100010	3
193	1010101001001	2	0100000010001	2	1010010010101	2	0100000100010	4
194	1010100101101	2	0100000001000	1	1010010001010	2	0100000010001	2
195	1010100101001	3	0010101010100	3	1010010000100	2	0100000001000	1
196	1010100101001	4	0010101010100	4	1010010000100	3	0010101010100	3
197	1010100100100	2	0010101001010	3	1010010000100	4	0010101010100	4
198	1010100010101	3	0010101001010	4	1010001000101	2	0010101001010	3
199	1010100010101	4	0010101000101	3	1010001000010	3	0010101001010	4
200	1010100010101	2	0010101000101	4	1010001000010	4	0010101000101	3
201	1010100001001	2	0010101000101	2	1010000101000	2	0010101000101	4
202	1010100000100	3	0010101000010	3	1010000100000	1	0010101000101	2
203	1010100000100	4	0010101000010	4	1001010101010	2	0010101000010	3
204	1010010101001	2	0010100100001	2	1001010101010	3	0010101000010	4
205	1010010101001	2	0010100100000	1	1001010101010	4	0010100100001	2
206	1010010010101	2	0010010101010	3	1001010101001	2	0010100100000	1
207	1010010000101	2	0010010101010	4	1001010101010	3	0010010101010	3
208	1010010000100	3	0010010100101	3	1001010010101	4	0010010101010	4
209	1010010000100	4	0010010100101	4	1001010010101	2	0010010100101	3
210	1010001000101	2	0010010100101	2	1001010001001	2	0010010100101	4
211	1010001000010	3	0010010100010	3	1001010000100	3	0010010100010	2
212	1010001000010	4	0010010100010	4	1001010000100	4	0010010100010	3
213	1010000100001	2	0010010010001	2	1001001010101	2	0010010100010	4
214	1010000010000	1	0010010001000	1	1001001001010	2	0010010010001	2
215	1001010101010	2	0010001010101	3	1001001000100	2	0010010001000	1
216	1001010101010	3	0010001010101	4	1001001000100	3	0010001010101	3
217	1001010101010	4	0010001010101	2	1001001000100	4	0010001010101	4
218	1001010100101	2	0010001010001	3	1001000100101	2	0010001010101	2
219	1001010010101	3	0010001010001	4	1001000100010	3	0010001010001	3
220	1001010010101	4	0010001001001	2	1001000100010	4	0010001010001	4
221	1001010010101	2	0010001000100	3	1001000010001	2	0010001001001	2
222	1001010000100	2	0010001000100	4	1001000001000	1	0010001000100	3
223	1001010000100	3	0010000101010	2	1000101010101	3	0010001000100	4
224	1001010000100	4	0010000101010	3	1000101010101	4	0010000101010	2
225	1001001010101	2	0010000101010	4	1000101010101	2	0010000101010	3
226	1001001001101	2	0010000100101	2	1000101001001	2	0010000101010	4
227	1001001000101	2	0010000100100	3	1000101000100	3	0010000100101	2
228	1001001000100	3	0010000100100	4	1000101000100	4	0010000100100	3
229	1001001000100	4	0010000101010	3	1000100101010	2	0010000100100	4
230	1001000100101	2	0010000101010	4	1000100100101	2	0010000101010	3
231	1001000100010	3	0010000100101	2	1000100100100	3	0010000101010	4
232	1001000100010	4	0010000100010	3	1000100100100	4	0010000100101	2
233	1001000010001	2	0010000100010	4	1000100010101	2	0010000100010	3
234	1001000001000	1	0010000010001	2	1000100010010	3	0010000100010	4
235	1000101010101	3	0010000001000	3	1000100010010	4	0010000010001	2
236	1000101010101	4	0010000001000	4	1000100001001	2	0010000001000	3
237	1000101010010	2	0001010100001	2	1000010101010	2	0010000001000	4
238	1000101001001	2	0001010010000	1	1000010101010	3	0001010100001	2
239	1000101000100	3	0001001010001	2	1000010100100	4	0001010010000	1
240	1000101000100	4	0001001010000	1	1000010010001	2	0001001010001	2
241	1000100101010	2	0001000101001	2	1000010010010	3	0001001001000	1
242	1000100101001	2	0001000101000	3	1000010010010	4	0001000101001	2
243	1000100010010	3	0001000100100	4	1000010001010	2	0001000101000	3
244	1000100010010	4	0001000101001	2	1000010001001	3	0001000101000	4
245	1000100010010	2	0001000100100	3	1000010001001	4	0001000101001	2
246	1000100010010	3	0001000100100	4	1000010000100	2	0001000100100	3
247	1000100010010	4	0001000010101	2	1000001010100	3	0001000100100	4
248	1000100000100	2	0001000010010	3	1000001010100	4	0001000010101	2
249	1000010101001	2	0001000010010	4	1000001000101	2	0001000010010	3
250	1000010010010	2	0001000001001	2	1000000101001	2	0001000010010	4
251	1000010001010	2	0001000000100	3	1000000100000	1	0001000001001	2
252	1000010000100	2	0001000000100	4	0100101010000	1	0001000000100	3
253	1000001000100	2	0000100000010	3	0100100101000	1	0001000000100	4
254	1000000100001	2	0000100000010	4	0100010000101	2	0101010101010	3
255	1000000010000	1	0000010000001	2	0100001000001	2	0101010101010	4

FIG. 13A

No	MCG1-2	Ncg 1-2	MCG2-2	Ncg 2-2	DCG1-2	Ncg 3-2	DCG2-2	Ncg 4-2
0	101010100000000	1	000001010000000	1	000001010000000	1	000100100000000	1
1	101000101000000	1	000000101000000	1	000001001000000	1	010101010000000	1
2	101000101000000	1	000000101000000	1	000010010000000	1	010100101000000	1
3	101000010100000	1	000000010100000	1	000000100100000	1	010100001010000	1
4	101000000101000	3	000100100000000	1	101010100000000	1	010100001010000	3
5	101000000101000	4	000001001000000	1	101000101000000	1	010100000101000	4
6	101000000010100	3	000000100100000	1	101000010100000	1	010100000010100	3
7	101000000010100	4	000000100010000	1	101000001010000	1	010100000010100	4
8	010100000000010	3	001010101000000	1	000001010000001	2	010100000001010	3
9	010100000000010	4	001010010100000	1	000000101000001	2	010100000001010	4
10	101000000001010	3	001010000000001	2	101000001010000	3	001010000000001	2
11	010010000000001	2	001010001010000	3	000001010000010	3	010100000000101	2
12	101000000001010	4	000101000000001	2	101000001010000	4	000101000000001	2
13	101010100000001	2	001010001010000	4	000001010000010	4	001010101000000	1
14	101000000000101	2	000001010000001	2	101000000101000	3	010100000000010	3
15	101001010000001	2	001010000010100	3	000010010000001	2	001010010100000	1
16	010101010000000	1	000001010000001	2	101000000101000	4	010100000000010	4
17	101000101000001	2	001010000101000	4	000001010000010	3	001010001010000	3
18	010100101000000	1	000000101000001	2	101000000001010	3	010010000000001	2
19	010100010100000	1	001010000001010	3	101000000101010	4	001010001010000	4
20	101000010100001	2	001010000001010	4	000001010000010	4	001010000101000	3
21	010100001010000	3	000000010100001	2	101000000000101	2	001010000000010	3
22	010100001010000	4	001010000000101	2	000010101010000	3	001010000101000	4
23	101000001010001	2	001000100000000	1	000001001000001	2	001010000001010	3
24	010100000010100	3	001010000000010	3	000010101010000	4	001010000000010	4
25	010100000010100	4	000010101010000	1	000001010010100	3	001010000001010	4
26	010100000001010	3	000101001010000	3	000010100101000	4	001010000000101	2
27	010100000001010	4	000010100101000	4	000010100010010	3	001000100000000	1
28	010100000000101	2	000101000010100	3	000001010001010	4	000101010100000	1
29	101010001000000	1	000101000010100	4	000010100000101	2	000101001010000	2
30	101000100100000	1	000101000010010	3	000010001000000	1	000101001010000	4
31	101000100100000	1	000101000010010	4	000000101010100	3	000101000010100	3
32	101000010001000	3	000101000000101	2	000001010101000	4	000101000010100	4
33	101000010001000	4	000100010000000	1	000001010001010	3	000101000010010	3
34	101000000100100	3	000001010101000	3	000001010010010	4	000101000010010	4
35	101000000010101	2	000001010101000	4	101010100000001	2	000101000000101	2
36	101000000000100	3	000001010010100	3	101000101000001	2	000100010000000	1
37	101000000000100	4	000001010010100	4	101000101000001	2	010101001010000	1
38	101000000100100	4	000001010001010	3	000001010001010	2	010100010010000	1
39	101000000100010	3	000001010010010	4	000001000100000	1	010100010010000	3
40	101000000100010	4	000001010000101	2	101010010000000	1	010100010010000	4
41	101000000001001	2	000010000100000	1	101001000100000	1	010100001001000	3
42	100101010000000	1	000000101010100	3	101000100100000	1	010100001001000	4
43	100100101000000	1	000000101010100	4	101000001001000	3	010100000100010	3
44	100100010100000	1	000000101001010	3	101000010010000	4	010100000100010	4
45	100100001010000	3	000000101001010	4	101000000100100	3	010100000010001	2
46	100100001010000	4	000000101000101	2	101000001000100	4	010010101000000	1
47	100100000000010	3	001010000000010	4	101000001010001	2	001001000000001	2
48	100100000000010	4	001001000000001	2	101000000101001	2	000101000000010	3
49	100010000000001	2	000101000000010	3	101000000010101	2	000101000000010	4
50	100100000100100	3	000001000100000	1	101000000100010	3	010010010100000	1
51	100100000100100	4	000000101010010	3	101000000010010	4	010010001010000	3
52	100100000010010	3	000000101010010	4	101000000001001	2	010010001010000	4
53	100100000010010	4	000000101001010	2	100101010000000	1	010010000100100	3
54	100100000001001	2	000000100010000	3	100100101000000	1	010010000100100	4
55	010101001000000	1	000000100010000	4	100100010100000	1	010010000010010	3
56	010100100100000	1	000000010101010	2	100100001010000	3	010010000010010	4
57	010100010010000	3	001010100100000	1	100100001010000	4	010010000000101	2
58	010101010000001	2	000101000000010	4	101000000000100	3	000100100000001	2
59	010100101000001	2	000100100000001	2	101000000000100	4	010101010000001	2
60	010100010100001	2	000010100000010	3	100100000000010	3	010100101000001	2
61	010100010010000	4	001010010010000	3	100100000010100	3	010000100000000	1
62	010100001001000	3	001010010010000	4	100100000010100	4	001010100100000	1
63	010100001001000	4	001010001001000	3	100100000001010	3	001010010010000	3
64	010100000100100	3	001010001001000	4	100100000001010	4	001010001001000	4
65	010100000100100	4	001010000100100	3	100100000000101	2	001010001001000	3
66	010100000010010	3	001010000100100	4	000001010100100	3	001010001001000	4
67	010100000010010	4	000001010000010	4	100100000000010	4	010100010100001	2
68	010100000001001	2	000010010000001	2	100010000000001	2	010100001010001	2
69	010100000000100	3	000001010000010	3	000001010101001	2	010100000100101	2
70	010001010100000	1	001010000010001	2	000001010100100	4	001010000100100	3
71	010001001010000	1	001001010100000	1	000001010010010	3	001010000100100	4
72	010010001010000	3	001001001010000	3	000001010010010	4	001010000001001	2
73	010010001010000	4	001001001010000	4	000001010001001	2	001001010100000	1
74	010100000000100	4	000001010000010	4	000001010010101	2	010100000000100	3
75	010010000000010	3	000001001000001	2	000001010000100	3	010100000000100	4
76	010010000000010	4	000000101000010	3	000001010000100	4	010010000000010	3
77	010010000101000	3	001001001010100	3	000010010101000	3	001001001010000	3
78	010010000101000	4	001001000101000	4	000010010101000	4	001001001010000	4
79	010010000001010	3	001001000101010	3	000010010010100	3	001001000101000	3
80	010001000000001	2	000000101000010	4	000010010000010	3	010010000000010	4
81	101010100000010	3	000000100100001	2	000010010000010	4	010001000000001	2
82	101010100000010	4	000000010100010	3	000001000100001	2	001010101000001	3
83	010010000001010	4	001001000101010	4	000010010010010	4	001001000101000	4
84	010010000000101	2	001001000000101	2	000010010000101	2	001001000010010	3
85	101010010000001	2	000000010100010	4	000001010101001	2	001010010100001	2
86	101001010000010	3	000000010001001	2	000001010000100	3	001010001010001	2
87	101001010000010	4	001010101000001	2	000001010001000	4	001010000101010	2
88	010000100000000	1	001000010000000	1	000010000100000	1	001001000010100	4
89	101010101010000	3	000101010010000	3	000001010100010	3	001001000000101	2

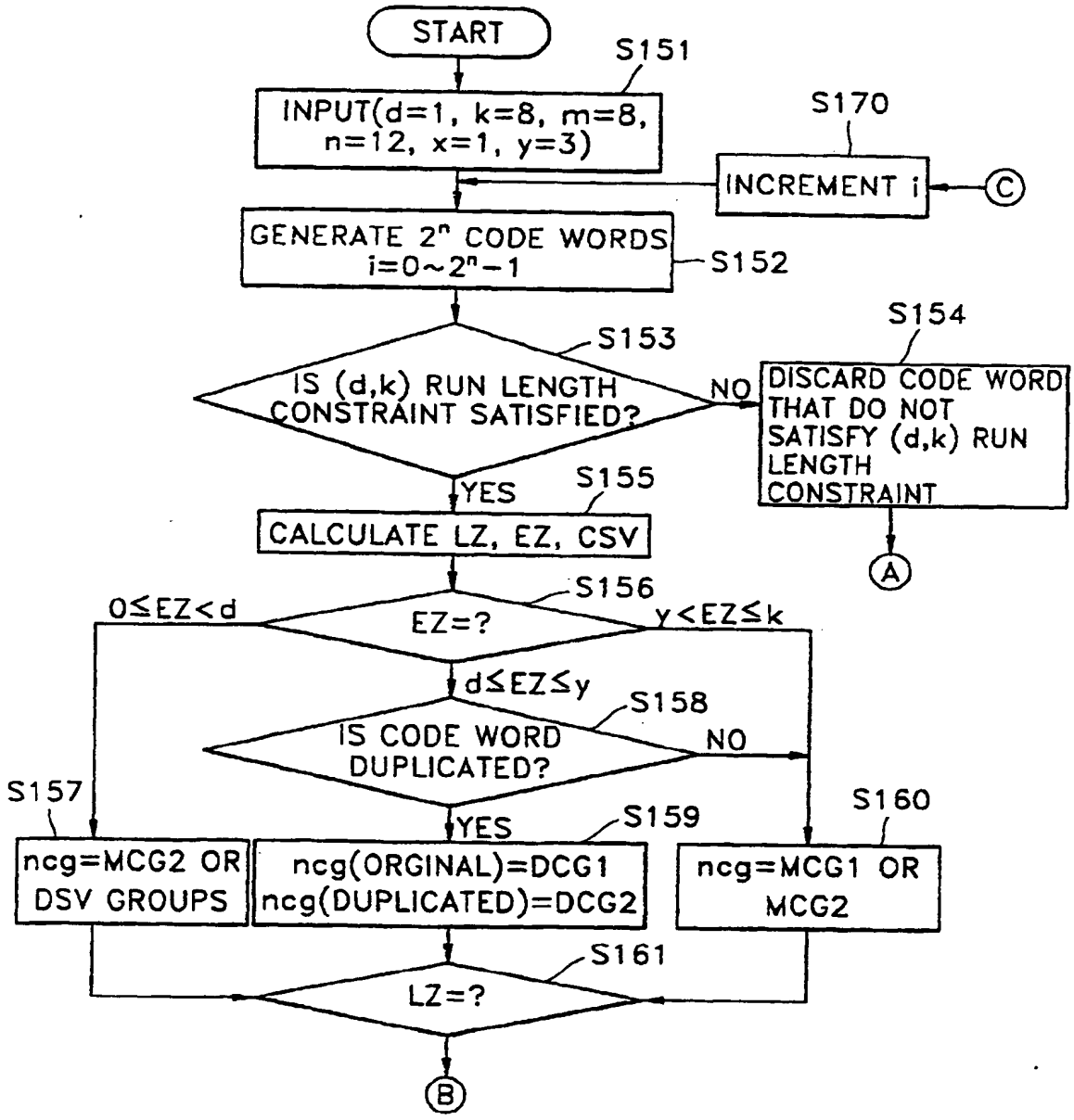
FIG. 13B

No	MCG1-2	Ncg 1-2	MCG2-2	Ncg 2-2	DCG1-2	Ncg 3-2	DCG2-2	Ncg 4-2
90	101010101001000	4	000101010001000	4	000001010100010	4	001000001000000	1
91	101001001000001	2	001010010100001	2	000001001000010	3	001010000000100	3
92	101010100101000	3	001010001010001	2	000001010001001	2	001010000000100	4
93	101000101000010	3	001010000101001	2	000001001000010	4	001001000000010	3
94	101010100101000	4	000101001001000	3	000001001010010	3	000101010001000	3
95	101010100201010	3	001010000001000	3	000001001010010	4	001001000000010	4
96	101000101000010	4	000101001001000	4	000001000100001	2	000101010001000	4
97	101010100001010	4	001010000001000	4	000001001001001	2	001000100000001	2
98	101010100000101	2	000101000100010	3	000001000010000	3	000101000100100	3
99	101000100100001	2	001001000000010	3	101010100000010	3	000101010100001	2
100	101010001000000	1	000101000100010	4	000001000010000	4	000101000100100	4
101	101001010101000	3	000101000010001	2	101010101010000	3	000101000100010	3
102	101001010101000	4	001001000000010	4	101010101010000	4	000101000101001	2
103	101000010100010	3	000100101010000	3	101010100000010	4	000101000100010	4
104	101000010100010	4	000100101010000	4	101010001000001	2	000101000001001	2
105	101001010001010	3	001000100000001	2	101010100101000	3	000101000101001	2
106	101001010001010	4	000100100101000	3	101010100101000	4	000100101010000	3
107	101000101000101	2	000100100101000	4	101010100001010	3	000100101010000	4
108	101001000100000	1	000100100001010	3	101010100101000	4	000100100101000	3
109	101000101010010	3	000101010100001	2	101010100000101	2	000101000000100	3
110	101000101010010	4	000101001010001	2	101010001000000	1	000101000000100	4
111	101000101000101	2	000100100001010	4	101000101010100	3	000100100101000	4
112	101000100001000	3	000100100000101	2	101001010101000	4	000100100101000	3
113	101000001001001	2	000100000100000	1	101000101000010	3	000100100001010	4
114	101000001010010	3	000010101001000	3	101001010000010	4	000100100000101	2
115	101000001010010	4	000001010100100	4	101001001000001	2	000100000100000	1
116	101000100001000	4	000001010010010	3	101001010001010	3	010101010101000	3
117	101000001001010	2	000001010010010	4	101000101000010	3	010101010101000	4
118	101000010101010	2	000001010001001	2	101000101001010	4	010101010001010	3
119	101000010000100	3	000101000101010	2	101001010001010	2	010101010001010	4
120	101000000001000	3	000101000000100	3	101000101000010	4	010101010000101	2
121	101000010000100	4	000101000000100	4	101001000100000	1	000100100000010	3
122	101000001000010	3	000100100000010	3	101000101010010	3	000100100000010	4
123	101000000001000	4	000010010101000	3	101000100100001	2	000100001000001	2
124	101000000100010	4	000010010101000	4	101000101010010	4	010101000100000	1
125	101000000100001	2	000010010000010	4	101000101000101	2	010100101010010	3
126	100101001000000	1	000001001001010	3	101000100001000	3	010101010000010	3
127	100101010000001	2	000001001001010	4	101000001010010	3	010100101010010	4
128	100100101000001	2	000100010000001	2	101000010100010	4	010100101000101	2
129	100100100100000	1	000001001000101	2	101000100010000	4	010101010000010	4
130	100100010001000	3	000010000100000	1	101000010101010	2	010100100010000	3
131	100100001001000	4	000000101010010	3	101000001000100	3	010100100001000	4
132	100100001001000	3	000001010101001	2	101000001000100	4	010100010101001	2
133	100100000100100	4	000001010010101	2	101000001000010	3	010101001000001	2
134	100100000010010	3	000000101010010	4	101000001000010	4	010100101000010	3
135	100100000010010	4	000000101001001	2	101000000010001	2	010100010000100	3
136	100100001010001	2	000000100101010	3	101000001001001	2	010100010000100	4
137	100100000101001	2	000000100101010	4	101000001010010	3	010100001000010	3
138	100100000101010	2	000000100100101	2	101000001010010	4	010100001000010	4
139	100100000001001	2	000000100001000	3	100101001000000	1	010100000010001	2
140	100100000000100	3	000000100001000	4	101000001000101	2	010010100100000	1
141	100001010100000	1	000001010000100	3	100100100100000	1	010010001001000	3
142	100010001010000	1	000001010000100	4	100100011001000	3	010100101000010	4
143	100100000000100	4	000010001000010	3	101000000001000	3	010100100010001	2
144	100010000101000	3	000000101010001	2	100100011001000	4	010100010100010	3
145	100010000101000	4	000010001000010	4	100100000100100	3	010010001001000	4
146	100010000101000	3	000000100101010	2	100100000100100	4	010100010100010	4
147	100010000000010	3	001010101010010	3	101000000001000	4	010010000100100	3
148	100010000000010	4	000010001000001	2	100101010000001	2	010010000100100	4
149	100010000101000	4	001010101010010	4	100100000100010	3	010100010001001	2
150	100010000101010	3	001010101000101	2	100100000100010	4	010010000100010	3
151	100010000101010	4	001010100001000	3	100100101000001	2	010010000100010	4
152	100010000000101	2	000001010101010	2	100100010100001	2	010010000001001	2
153	100000010000000	1	000001010001000	3	100100000101001	2	010100000101010	3
154	100001000000001	2	001010100001000	4	100100000001001	2	010100000101010	4
155	010101010000010	3	001010010101010	2	100100000100101	2	010001010100000	1
156	010101010000010	4	001010010001000	3	100010101000000	1	010001001010000	3
157	010101010101000	3	001010010001000	4	100100000001000	3	010001001010000	4
158	010101001000001	2	001010000100010	3	100100000001000	4	010001000101000	3
159	010101010101000	4	000001010001000	4	100010010100000	1	010001000101000	4
160	010101010001010	3	000000100100010	3	100010000000010	3	010100001001010	2
161	010101010001010	4	000001001000010	4	100010000000010	4	010100000010000	3
162	010100101000010	3	001010001000010	4	100001000000001	2	010100000001000	4
163	010100101000010	4	000001000101001	2	100010001010000	3	010001000010010	3
164	010101010001001	2	001010000010001	2	000010101010010	3	010010101000001	2
165	010101000010000	1	001001010001000	3	000010101001010	4	010001000001010	4
166	010100101010010	3	001001010001000	4	100010001010000	4	010001000000101	2
167	010100100010001	2	000000101001000	3	000010101001001	2	010000010000000	1
168	010100010100010	3	000000101001000	4	000010100010000	3	010001001010001	2
169	010100010100010	4	001001001001000	3	000010100010000	4	010010001010001	2
170	010100101010010	4	001001001001000	4	000010010101001	2	001010101010010	3
171	010100101001001	2	001001000010010	3	000010001000100	3	001010101010010	4
172	010100100001000	3	000000100010010	3	000010010001000	4	001010101001001	2
173	010100010010001	2	000000100010010	4	000010001001010	3	010010000101001	2
174	010100000101010	3	000000100001001	2	000010001001010	4	010010000001000	3
175	010100100010000	4	001001000010010	4	100010000101000	3	010010000001000	4
176	010100000101010	4	001001000001001	2	000010000010001	2	001010100001000	3
177	010100000100101	2	001000101010000	3	000001010001000	3	001010100001000	4
178	010100000010000	3	000000010101000	3	100010000101000	4	001010010101001	2
179	010100001010101	2	000000001010100	4	000001010001000	4	010001000000010	3

FIG. 13C

No	MCG1-2	Ncg 1-2	MCG2-2	Ncg 2-2	DCG1-2	Ncg 3-2	DCG2-2	Ncg 4-2
180	01010001000100	3	00100010101000	4	00000100100100	3	01000100000010	4
181	01010000001000	4	00000001001010	3	00000100100100	4	00101001000100	3
182	01001010100001	2	00000001001010	4	10001000001010	3	01000010000001	2
183	01001001010001	2	00101010100010	3	00000100010010	3	00101010100010	3
184	01001000101001	2	00100010010100	3	00000100010010	4	00101010100010	4
185	01001000010101	2	00100010010100	4	00000100001001	2	00101001000100	4
186	01010001000100	4	00101010100010	4	10101010101001	2	00101000100010	3
187	01010000100010	3	00101010010001	2	10101010010101	2	00101010010001	2
188	01010000100010	4	00101001010010	3	10101010000100	3	00101001010010	3
189	01001000000100	3	00101001010010	4	10001000001010	4	00101001010010	4
190	01010000010001	2	00101001001001	2	10101010000100	4	00101001001001	2
191	01001000000100	4	00100010001010	3	10101001000010	3	00101000101010	3
192	01000100000010	3	00100010001010	4	10101001000010	4	00101000100010	4
193	01000100000010	4	00100010000101	2	10101000100001	2	00101000010001	2
194	01001010010000	1	00101000101010	3	10100101010101	2	00100101001000	3
195	01000010000001	2	00100000100000	1	10001000000101	2	00101000101010	4
196	10101010010101	2	00001010101101	2	10100101000100	3	00100101001000	4
197	10101010000100	3	00010101000100	3	10100101000100	4	00100100100100	3
198	10101010000100	4	00010101000100	4	10000010000000	1	00100100100100	4
199	10101001000010	3	00010100100010	3	10100100100010	3	00100100010010	3
200	10101001000010	4	00010100100010	4	10100100100010	4	00100100010010	4
201	01001001001000	3	00010100010001	2	10100100010001	2	00100100001001	2
202	10101000100001	2	00101000101010	4	00001010100010	3	00100010101000	3
203	10100101010101	2	00101000100101	2	00001010100010	4	00101000100101	2
204	10100101000100	3	00101000001000	3	10100010100100	3	00101000001000	3
205	10100101000100	4	00010010100100	3	10100010100100	4	00101000001000	4
206	10100100100010	3	00010010100100	4	10100010010010	3	00100010101000	4
207	01001001001000	4	00010010010010	3	10100010010010	4	00100010010100	3
208	10100100100010	4	00010010010010	4	10100010001001	2	00100010010100	4
209	10100100010001	2	00010010001001	2	10100001010100	3	00100010001010	3
210	01001000100100	3	00010001010100	3	00001010010001	2	00100010001010	4
211	10100010100100	3	00101000001000	4	10100001010100	4	00100010000101	2
212	10100010100100	4	00100101010001	2	10100001001010	3	00100101010001	2
213	10100010010010	3	00100100101001	2	10100001001010	4	00100100101001	2
214	01001000100100	4	00010001010100	4	10100001000101	2	00100100010101	2
215	01001000010010	3	00010001001010	3	00001001010010	3	00100000100000	1
216	10100010010010	4	00010001001010	4	10100000010000	1	00010101010101	2
217	10100010001001	2	00010001000101	2	10010101000010	3	00010101000100	3
218	10100001010100	3	00100100010101	2	00001001010010	4	00010101000100	4
219	10100001010100	4	00100100000100	3	10010101000010	4	00100100000100	3
220	10100001001010	3	00100100000100	4	10010100100001	2	00100100000100	4
221	10100001001010	4	00010000010000	1	10010010100010	3	00100010000010	3
222	01001000010010	4	00001010100010	3	00001001001001	2	00010100100010	3
223	10100001000101	2	00001010100010	4	10010010100010	4	00010100100010	4
224	10100000010000	1	00100010000010	3	10010010010001	2	00010100010001	2
225	10010101000010	3	00100010000010	4	10010001010010	3	00100010000010	4
226	10010101000010	4	00100001000001	2	00001000101010	3	00100001000001	2
227	01001000001001	2	00001010010001	2	10010001010010	4	00010101010010	3
228	10010100100001	2	00001001010010	3	10010001001001	2	00010010100100	3
229	10010010100010	3	00010101010010	3	10010000101010	3	00010010100100	4
230	01000101010000	1	00010101010010	4	00001000101010	4	00010101010010	4
231	10010010100010	4	00010101001001	2	10010000101010	4	00010101001001	2
232	10010010010001	2	00001001010010	4	10010000100101	2	00010100101010	3
233	10010001010010	3	00001001001001	2	00001000100101	2	00010010010010	3
234	01000100101000	3	00001000101010	3	10010000001000	3	00010010010010	4
235	10010001010010	4	00010100101010	3	10010000001000	4	00010010001001	2
236	10010001001001	2	00010100101010	4	10001010100001	2	00010100101010	4
237	10010000101010	3	00001001001010	2	00001000001000	3	00010100100101	2
238	01000100101000	4	00001000101010	4	10001001010001	2	00010010100100	3
239	10010000101010	4	00010100001000	3	10001000101001	2	00010010010100	3
240	10010000100101	2	00001000100101	2	00001000001000	4	00010100001000	4
241	10010000001000	3	00010100001000	4	10001000010101	2	00010010010100	4
242	01000100010100	3	00001000001000	3	10001000000100	3	00010010101001	2
243	10010000001000	4	00001000001000	4	00000101010001	2	00010001001010	3
244	10001010100001	2	00010010101001	2	10001000000100	4	00010001001010	4
245	01000100010100	4	00000101010001	2	10000100000010	3	00010010010101	2
246	10001001010001	2	00000100101001	2	10000100000010	4	00010001000101	2
247	10001000101001	2	00010010010101	2	10000010000001	2	00010000010000	1
248	10001000010101	2	00000100010101	2	00001010010000	1	00010010000100	3
249	01000100001010	3	00000100000100	3	00001000001001	2	01010101001001	2
250	01000100001010	4	00000100000100	4	00000100101001	2	01010100101010	3
251	01000100000101	2	00010010000100	3	00000101010000	1	01010100101010	4
252	10001000000100	3	00010010000100	4	00000100010101	2	00010010000100	4
253	10001000000100	4	00010001000010	3	00000100000100	3	00010001000010	3
254	01000001000000	1	00010001000010	4	00000100000100	4	00010001000010	4
255	10000010000001	2	00010000100001	2	00000100000101	2	00010000100001	2

FIG. 14A



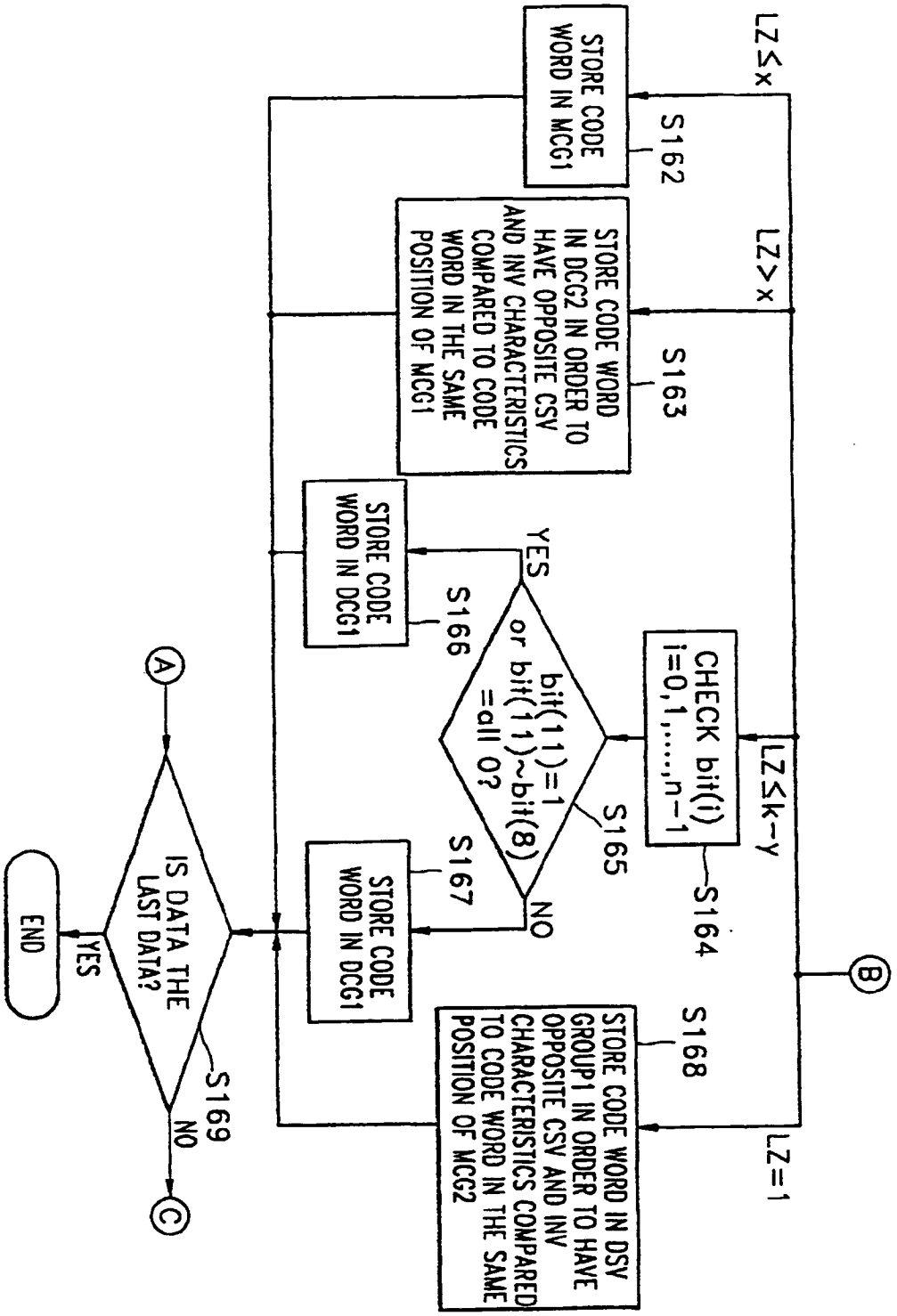


FIG. 14B

FIG. 15A

Data Symbol	MCG1 Code Word MSB LSB	MCG1 NCG	MCG2 Code Word MSB LSB	MCG2 NCG	DCG1 Code Word MSB LSB	DCG1 NCG	DCG2 Code Word MSB LSB	DCG2 NCG
000	101010000000	1	001010000000	1	101010000000	1	001010000000	1
001	100101000000	1	000101000000	1	100101000000	1	000101000000	1
002	100010100000	1	000010100000	1	100010100000	1	010000000010	3
003	100001010000	1	000001010000	1	100001010000	1	010000000010	4
004	100000101000	3	000000101000	3	100000101000	3	010000001000	3
005	100000101000	4	000000101000	4	100000101000	4	010000010001	2
006	100000010100	3	000000010100	3	100000010100	3	010000010010	3
007	100000010100	4	000000010100	4	100000010100	4	010000010010	4
008	100000001010	1	001001000000	1	100000001010	3	001001000000	1
009	100000000101	2	000100100000	1	100000000101	2	000100100000	1
010	010101000000	1	000010010000	1	000010010000	1	010101000000	1
011	010010100000	1	000001001000	3	000001001000	3	010010100000	1
012	010001010000	1	000001001000	4	000001001000	4	010001010000	1
013	010000101000	3	000000100100	3	100000001010	4	010000101000	3
014	010000101000	4	000000100100	4	100000010010	3	010000101000	4
015	010000010100	3	000000010010	3	100000100010	3	010000010100	3
016	010000010100	4	000000010010	4	100000101010	3	010000010100	4
017	010000001010	3	010100010100	3	100001000010	3	010000001010	3
018	010000001010	4	010100010100	4	100001001010	3	010000001010	4
019	010000000101	2	010100001010	3	100001010010	3	010000000101	2
020	010000000010	3	001010000001	2	100010000010	3	001010000001	2
021	010000000010	4	000101000001	2	100010001010	3	000101000001	2
022	010010000000	1	001010100000	1	100010010010	3	001010100000	1
023	010100000001	2	001000000001	2	100010100010	3	001000000001	2
024	101010000001	2	000010100001	2	101010000001	2	010000100010	3
025	101001000000	1	010100001010	4	101001000000	1	010100001010	3
026	101000000001	2	001000000010	3	101000000001	2	001000000010	3
027	100101000001	2	000001010001	2	100101000001	2	010000100010	4
028	100100100000	1	010100000101	2	100100100000	1	010100000101	2
029	100010100001	2	000000101001	2	100010100001	2	010000100100	3
030	100010010000	1	010001000000	1	100010010000	1	010001000000	1
031	100001010001	2	000000010101	2	100001010001	2	010000100100	4
032	100001001000	3	001010101000	3	100001001000	3	001010101000	3
033	100001001000	4	001010101000	4	100001001000	4	001010101000	4
034	100000101001	2	010010000001	2	100000101001	2	010010000001	2
035	100000100100	3	001010010100	3	100000100100	3	001010010100	3
036	100000100100	4	001010010100	4	100000100100	4	001010010100	4
037	100000010101	2	001010000010	3	100000010101	2	001010000010	3
038	100000010010	1	001010001010	3	100000010010	4	001010001010	3
039	100000001001	2	001010001010	4	100000001001	2	001010001010	4
040	100000000100	3	001010000010	4	100000000100	3	001010000010	4
041	100000000100	4	001001000001	2	100000000100	4	001001000001	2
042	010101000001	2	000101000010	3	100010101010	3	000101000010	3
043	010100100000	1	001010000101	2	100100000010	3	001010000101	2
044	010010100001	2	000101000010	4	100100001010	3	000101000010	4
045	010010010000	1	001000100000	1	100100010010	3	001000100000	1
046	010001010001	2	000100100001	2	100100100010	3	000100100001	2
047	010001001000	3	000101010100	3	100100101010	3	000101010100	3
048	010001001000	4	000101010100	4	100101000010	3	000101010100	4
049	010000101001	2	000010100010	3	000010100010	3	010000101001	2
050	010000100100	3	000101001010	3	100101001010	3	000101001010	3
051	010000100100	4	000101001010	4	100101010010	3	000101001010	4
052	010000010101	2	000010100010	4	000010100010	4	010000010101	2
053	010000010010	3	000101000101	2	000001000000	1	000101000101	2
054	010000010010	4	000100010000	1	000001000001	2	000100010000	1
055	010000001001	2	000010101010	3	000010101010	3	010000001001	2
056	010000000100	3	000010010001	2	000010010001	2	010000000100	3
057	010000000100	4	000001010010	3	000001010010	3	010000000100	4
058	010100000010	3	001000000010	4	000001000010	3	001000000010	4
059	010100000010	4	000100000001	2	000001000010	4	000100000001	2
060	010100101000	3	001001010000	1	000001000100	3	001001010000	1

FIG. 15B

Data Symbol	MCG1 Code Word MSB LSB	MCG1 NCG	MCG2 Code Word MSB LSB	MCG2 NCG	DCG1 Code Word MSB LSB	DCG1 NCG	DCG2 Code Word MSB LSB	DCG2 NCG
061	010100101000	4	001000101000	3	000001000100	4	001000101000	3
062	010101010000	1	001000101000	4	000001000101	2	001000101000	4
063	101010101000	3	000010101010	4	101010101000	3	010000100101	2
064	101010101000	4	000010100101	2	101010101000	4	010000101010	3
065	101010100000	1	001000010100	3	101010100000	1	001000010100	3
066	101010010100	3	000010001000	3	101010010100	3	010000101010	4
067	101010010100	4	000010001000	4	101010010100	4	010001000100	3
068	101010001010	3	000001010101	2	101010001010	3	010001000100	4
069	101010001010	4	000001000100	3	101010001010	4	010001001000	3
070	101010000101	2	000001000100	4	101010000101	2	010001001000	4
071	101010000010	3	000001010010	4	101010000010	3	010001001001	2
072	101010000010	4	000001001001	2	101010000010	4	010001010001	2
073	101001010000	1	001000010100	4	101001010000	1	001000010100	4
074	101001000001	2	000000101010	3	101001000001	2	010001010010	3
075	101000101000	3	001000001010	3	101000101000	3	001000001010	3
076	101000101000	4	001000001010	4	101000101000	4	001000001010	4
077	101000100000	1	000000100010	3	101000100000	1	010001010010	4
078	101000010100	3	001000000101	2	101000010100	3	001000000101	2
079	101000010100	4	000010000000	1	101000010100	4	010001010101	2
080	101000001010	3	001010010000	1	101000001010	3	001010010000	1
081	101000001010	4	001001001000	3	101000001010	4	001001001000	3
082	101000000101	2	001001001000	4	101000000101	2	001001001000	4
083	101000000010	3	001010100001	2	101000000010	3	001010100001	2
084	101000000010	4	001001010001	2	101000000010	4	001001010001	2
085	100101010100	3	000000100010	4	100101010100	3	010010000000	1
086	100101010100	4	000000010001	2	100101010100	4	010010001000	3
087	100101001010	1	010101001000	3	100101001010	4	010101001000	3
088	100101000101	2	010101001000	4	100101000101	2	010101001000	4
089	100101000010	1	000000101010	4	100101000010	4	010010001000	4
090	100100100001	2	000000100101	2	100100100001	2	010010010000	1
091	100100010000	1	010100100100	3	100100010000	1	010100100100	3
092	100100000001	2	001000101001	2	100100000001	2	001000101001	2
093	100010101010	1	010100100100	4	100010101010	4	010100100100	4
094	100010100101	2	010100010010	3	100010100101	2	010100010010	3
095	100010100010	1	010101010001	2	100010100010	4	010101010001	2
096	100010010001	2	010100101001	2	100010010001	2	010100101001	2
097	100010001000	3	010100010010	4	100010001000	3	010100010010	4
098	100010001000	4	010100001001	2	100010001000	4	010100001001	2
099	100010000000	1	001000100100	3	100010000000	1	001000100100	3
100	100001010101	2	010010101000	3	100001010101	2	010010101000	3
101	100001010010	1	010100010101	2	100001010010	4	010100010101	2
102	100001001001	2	010100000100	3	100001001001	2	010100000100	3
103	100001000100	3	010010101000	4	100001000100	3	010010101000	4
104	100001000100	4	010010010100	3	100001000100	4	010010010100	3
105	100000101010	1	010100000100	4	100000101010	4	010100000100	4
106	100000100101	2	010010000010	3	100000100101	2	010010000010	3
107	100000100010	1	010010010100	4	100000100010	4	010010010100	4
108	100000010001	2	010010001010	3	100000010001	2	010010001010	3
109	100000001000	3	010010000010	4	100000001000	3	010010000010	4
110	100000001000	4	010001000001	2	100000001000	4	010001000001	2
111	010100100001	2	001010101001	2	000001001001	2	001010101001	2
112	010101000101	2	010010001010	4	000001001010	3	010010001010	4
113	010100010000	1	010010000101	2	000001001010	4	010010000101	2
114	010010100010	3	001010010101	2	000001010000	1	001010010101	2
115	010010100010	4	001010000100	3	000001010001	2	001010000100	3
116	010010100101	2	010000100000	1	000001010010	4	010000100000	1
117	010010010001	2	001010000100	4	000001010100	3	001010000100	4
118	010001001000	3	001010100100	3	000001010100	4	001010100100	3
119	010010001000	4	001010100100	4	000001010101	2	001010100100	4
120	010001010101	2	001010010010	3	000010000000	1	001010010010	3

FIG. 15C

Data Symbol	MCG1		MCG2		DCG1		DCG2	
	Code Word MSB LSB	NCG	Code Word MSB LSB	NCG	Code Word MSB LSB	NCG	Code Word MSB LSB	NCG
121	010001010010	3	001001000010	3	000010000001	2	001001000010	3
122	010001010010	4	001001000010	4	000010000010	3	001001000010	4
123	010001001001	2	001000100001	2	000010000010	4	001000100001	2
124	010001000100	3	001010010010	4	000010000100	3	001010010010	4
125	010001000100	4	001010001001	2	000010000100	4	001010001001	2
126	010000010001	2	001001010100	3	000010000101	2	001001010100	3
127	010101010100	3	001001010100	4	000010001000	3	001001010100	4
128	010101010100	4	001001001010	3	000010001000	4	001001001010	3
129	010101000010	3	000101010101	2	000010001001	2	000101010101	2
130	010101000010	4	000101000100	3	000010001010	3	000101000100	3
131	010010101010	3	001001001010	4	000010001010	4	001001001010	4
132	010010101010	4	001001000101	2	000010010010	3	001001000101	2
133	010101001010	3	001000010000	1	000010010010	4	001000010000	1
134	010101001010	4	000101010010	3	000010010100	3	000101010010	3
135	010000101010	3	000101000100	4	000010010100	4	000101000100	4
136	010000101010	4	000100100010	3	000010010101	2	000100100010	3
137	010000100101	2	000100100010	4	000010100000	1	000100100010	4
138	010000100010	3	000101010010	4	000010100001	2	000101010010	4
139	010000100010	4	000101001001	2	000010100100	3	000101001001	2
140	010000001000	3	000100010001	2	000010100101	2	000100010001	2
141	010000001000	4	000010100100	3	000010100100	4	010000001000	4
142	101010101001	2	000010100100	4	101010101001	2	010010010001	2
143	101010100100	3	000100101010	3	101010100100	3	000100101010	3
144	101010100100	4	000100101010	4	101010100100	4	000100101010	4
145	101010100001	2	001000010101	2	101010100001	2	001000010101	2
146	101010010101	2	000010010010	3	101010010101	2	010010100001	2
147	101010010010	3	000100100101	2	101010010010	3	000100100101	2
148	101010010010	4	000100001000	3	101010010010	4	000100001000	3
149	101010010000	1	001000100100	4	101010010000	1	001000100100	4
150	101010001001	2	000100001000	4	101010001001	2	000100001000	4
151	101010000100	3	000010010010	4	101010000100	3	010010100010	3
152	101010000100	4	000010001001	2	101010000100	4	010010100010	4
153	101001010100	3	000010101001	2	101001010100	3	010010100101	2
154	101001010100	4	000010010101	2	101001010100	4	010010101010	3
155	101001010001	2	001000000100	3	101001010001	2	001000000100	3
156	101001001010	3	000010000100	3	101001001010	3	010010101010	4
157	101001001010	4	000010000100	4	101001001010	4	010100000001	2
158	101001001000	3	001000010010	3	101001001000	3	001000010010	3
159	101001001000	4	001000010010	4	101001001000	4	001000010010	4
160	101001000101	2	000001000010	3	101001000101	2	010100000010	3
161	101001000010	3	000001010100	3	101001000010	3	010100000010	4
162	101001000010	4	000001010100	4	101001000010	4	010100001010	4
163	101000101001	2	001000000100	4	101000101001	2	001000000100	4
164	101000100100	3	001000001001	2	101000100100	3	001000001001	2
165	101000100100	4	000101010000	1	101000100100	4	000101010000	1
166	101000100001	2	000001001010	3	101000100001	2	010100010000	1
167	101000010101	2	000100000010	3	101000010101	2	000100000010	3
168	101000010010	3	000100101000	3	101000010010	3	000100101000	3
169	101000010010	4	000100101000	4	101000010010	4	000100101000	4
170	101000010000	1	000001000010	4	101000010000	1	010100010100	3
171	101000001001	2	000100010100	3	101000001001	2	000100010100	3
172	101000000100	3	000100000010	4	101000000100	3	000100000010	4
173	101000000100	4	000010000001	2	101000000100	4	010100010100	4
174	100101010101	2	000001001010	4	100101010101	2	010100100000	1
175	100101010010	1	000000100001	2	100101010010	4	010100100001	2
176	100101010000	1	000100010100	4	100101010000	1	000100010100	4
177	100101001001	2	010101010101	2	100101001001	2	010100101000	3
178	100101000100	3	000001000101	2	100101000100	3	010100101000	4
179	100101000100	4	000000010000	1	100101000100	4	010100101010	3
180	100100101010	1	010100100010	3	100100101010	4	010100100010	3

FIG. 15D

Data Symbol	MCG1 Code Word MSB LSB	MCG1 NCG	MCG2 Code Word MSB LSB	MCG2 NCG	DCG1 Code Word MSB LSB	DCG1 NCG	DCG2 Code Word MSB LSB	DCG2 NCG
181	100100101000	3	000100001010	3	100100101000	3	000100001010	3
182	100100101000	4	000100001010	4	100100101000	4	000100001010	4
183	100100100101	2	010100100010	4	100100100101	2	010100100010	4
184	100100100010	1	010101010010	3	100100100010	4	010101010010	3
185	100100010100	3	000100000101	2	100100010100	3	000100000101	2
186	100100010100	4	000001000000	1	100100010100	4	010100101010	4
187	100100010001	2	010101010010	4	100100010001	2	010101010010	4
188	100100001010	1	010101001001	2	100100001010	4	010101001001	2
189	100100001000	3	010100010001	2	100100001000	3	010100010001	2
190	100100001000	4	010010100100	3	100100001000	4	010010100100	3
191	100100000101	2	010100100101	2	100100000101	2	010100100101	2
192	100100000010	1	010010100100	4	100100000010	4	010010100100	4
193	100010101001	2	010010010010	3	100010101001	2	010010010010	3
194	100010100100	3	010100001000	3	100010100100	3	010100001000	3
195	100010100100	4	010100001000	4	100010100100	4	010100001000	4
196	100010010101	2	010010010010	4	100010010101	2	010010010010	4
197	100010010010	1	010010101001	2	100010010010	4	010010101001	2
198	100010001001	2	010010010101	2	100010001001	2	010010010101	2
199	100010000100	3	010010001001	2	100010000100	3	010010001001	2
200	100010000100	4	010001010100	3	100010000100	4	010001010100	3
201	100010000001	2	010001010100	4	100010000001	2	010001010100	4
202	100001010100	3	010010000100	3	100001010100	3	010010000100	3
203	100001010100	4	010010000100	4	100001010100	4	010010000100	4
204	100001001010	1	010001000010	3	100001001010	4	010001000010	3
205	100001000101	2	010001000010	4	100001000101	2	010001000010	4
206	100001000010	1	010001001010	3	100001000010	4	010001001010	3
207	100001000000	1	010000100001	2	100001000000	1	010000100001	2
208	100000100001	2	010001001010	4	100000100001	2	010001001010	4
209	100000010000	1	001010101010	3	100000010000	1	001010101010	3
210	010101000100	3	001010101010	4	000010101000	3	001010101010	4
211	010101000100	4	001010100101	2	000010101000	4	001010100101	2
212	010100101010	3	010001000101	2	000010101001	2	010001000101	2
213	010100101010	4	010000010000	1	000010101010	4	010000010000	1
214	101010101010	3	001010001000	3	101010101010	3	001010001000	3
215	101010101010	4	001010001000	4	101010101010	4	001010001000	4
216	101010100101	2	001000101010	2	101010100101	2	001001010101	2
217	101010100010	3	001010100010	3	101010100010	3	001010100010	3
218	101010100010	4	001010100010	4	101010100010	4	001010100010	4
219	101010010001	2	001010010001	2	101010010001	2	001010010001	2
220	101010001000	3	001001000100	3	101010001000	3	001001000100	3
221	101010001000	4	001001000100	4	101010001000	4	001001000100	4
222	101001010101	2	001000100010	3	101001010101	2	001000100010	3
223	101001010010	3	001001010010	3	101001010010	3	001001010010	3
224	101001010010	4	001001010010	4	101001010010	4	001001010010	4
225	101001001001	2	001001001001	2	101001001001	2	001001001001	2
226	101001000100	3	001000100010	4	101001000100	3	001000100010	4
227	101001000100	4	001000010001	2	101001000100	4	001000010001	2
228	101000101010	3	001000101010	3	101000101010	3	001000101010	3
229	101000101010	4	001000101010	4	101000101010	4	001000101010	4
230	101000100101	2	001000100101	2	101000100101	2	001000100101	2
231	101000100010	3	000101001000	3	101000100010	3	000101001000	3
232	101000100010	4	000101001000	4	101000100010	4	000101001000	4
233	101000010001	2	000100100100	3	101000010001	2	000100100100	3
234	101000001000	3	001000001000	3	101000001000	3	001000001000	3
235	101000001000	4	001000001000	4	101000001000	4	001000001000	4
236	100101010001	2	000101010001	2	100101010001	2	000101010001	2
237	100101001000	3	000100100100	4	100101001000	3	000100100100	4
238	100101001000	4	000100010010	3	100101001000	4	000100010010	3
239	100100101001	2	000100101001	2	100100101001	2	000100101001	2
240	100100100100	3	000100010010	4	100100100100	3	000100010010	4

FIG. 15E

Data Symbol	MCG1		MCG2		DCG1		DCG2	
	Code Word MSB LSB	NCG	Code Word MSB LSB	NCG	Code Word MSB LSB	NCG	Code Word MSB LSB	NCG
241	100100100100	4	000100001001	2	100100100100	4	000100001001	2
242	100100010101	2	000100010101	2	100100010101	2	000100010101	2
243	100100010010	1	000010101000	3	100100010010	4	010101000001	2
244	100100001001	2	000010101000	4	100100001001	2	010101000010	3
245	100100000100	3	000100000100	3	100100000100	3	000100000100	3
246	100100000100	4	000100000100	4	100100000100	4	000100000100	4
247	100010101000	3	000010010100	3	100010101000	3	010101000010	4
248	100010101000	4	000010010100	4	100010101000	4	010101000100	3
249	100010010100	3	000010001010	3	100010010100	3	010101000100	4
250	100010010100	4	000010001010	4	100010010100	4	010101000101	2
251	100010001010	1	000010000101	2	100010001010	4	010101001010	3
252	100010000101	2	000000100000	1	100010000101	2	010101001010	4
253	100010000010	1	000010000010	3	100010000010	4	010101010000	1
254	100001000001	2	000010000010	4	100001000001	2	010101010100	3
255	100000100000	1	000001000001	2	100000100000	1	010101010100	4

FIG. 16

Data Symbol	DSV Code Group		Data Symbol	DSV Code Group	
	Code Word MSB LSB	NCG		Code Word MSB LSB	NCG
000	010101000000	1	035	010001000100	3
001	010010100000	1	036	010001000100	4
002	010001010000	1	037	010000000100	3
003	010000101000	3	038	010000010001	2
004	010000101000	4	039	010101010100	3
005	010000010100	3	040	010000000100	4
006	010000010100	4	041	010100100001	2
007	010000001010	3	042	010010100010	3
008	010000001010	4	043	010101010100	4
009	010000000101	2	044	010010100010	4
010	010100100000	1	045	010010101010	3
011	010010010000	1	046	010010010001	2
012	010001001000	3	047	010010101010	4
013	010001001000	4	048	010101001010	3
014	010000100100	3	049	010001010010	3
015	010000100100	4	050	010101001010	4
016	010000010010	3	051	010000100010	3
017	010000010010	4	052	010001010010	4
018	010000001001	2	053	010000100010	4
019	010101000101	2	054	010100101010	3
020	010000000010	3	055	010100101010	4
021	010000000010	4	056	010001001001	2
022	010010000000	1	057	010101000010	3
023	010100000001	2	058	010100000010	4
024	010101000001	2	059	010100101000	3
025	010100010000	1	060	010100101000	4
026	010100000010	3	061	010101010000	1
027	010010100001	2	062	010101000010	2
028	010010100101	2	063	010000101010	3
029	010001010001	2	064	010000101010	4
030	010010001000	3	065	010000100101	2
031	010000101001	2	066	010000001000	3
032	010010001000	4	067	010000001000	4
033	010001010101	2	068	010101000100	2
034	010000010101	2	069	010101000100	1

FIG. 17A

Data Symbol	MCG1 Code Word MSB LSB	MCG1 NCG	MCG2 Code Word MSB LSB	MCG2 NCG	DCG1 Code Word MSB LSB	DCG1 NCG	DCG2 Code Word MSB LSB	DCG2 NCG
000	0101010000000	1	x001010000000	1	0101010000000	1	x001010000000	1
001	0100101000000	1	x000101000000	1	0100101000000	1	x000101000000	1
002	0100010100000	1	x000010100000	1	0100010100000	1	x010000000010	3
003	0100001010000	1	x000001010000	1	0100001010000	1	x010000000010	4
004	0100000101000	3	x000000101000	3	0100000101000	3	x010000001000	3
005	0100000101000	4	x000000101000	4	0100000101000	4	x010000010001	2
006	0100000010100	3	x000000010100	3	0100000010100	3	x010000010010	3
007	0100000010100	4	x000000010100	4	0100000010100	4	x010000010010	4
008	0100000001010	1	x001001000000	1	0100000001010	3	x001001000000	1
009	0100000000101	2	x000100100000	1	0100000000101	2	x000100100000	1
010	x0101010000000	1	x000010010000	1	x000010010000	1	x010101000000	1
011	x0100101000000	1	x000001001000	3	x000001001000	3	x010010100000	1
012	x0100010100000	1	x000001001000	4	x000001001000	4	x010001010000	1
013	x0100001010000	3	x000000100100	3	0100000001010	4	x010000101000	3
014	x0100001010000	4	x000000100100	4	0100000010010	3	x010000101000	4
015	x0100000101000	3	x000000010010	3	0100000100010	3	x010000010100	3
016	x0100000101000	4	x000000010010	4	0100000101010	3	x010000010100	4
017	x0100000010100	3	x001010001010	3	0100001000010	3	x010000001010	3
018	x0100000010100	4	x001010001010	4	0100001001010	3	x010000001010	4
019	x0100000001010	2	x001010001010	3	0100001010010	3	x010000000101	2
020	x0100000000101	3	x000101000001	2	0100010000010	3	x001010000001	2
021	x0100000000101	4	x000101000001	2	0100010001010	3	x000101000001	2
022	x0100100000000	1	x001010100000	1	0100010010010	3	x001010100000	1
023	x0101000000001	2	x001000000001	2	0100010100010	3	x001000000001	2
024	0101010000001	2	x000010100001	2	0101010000001	2	x010000100010	3
025	0101001000000	1	x001010001010	4	0101001000000	1	x010100001010	3
026	0101000000001	2	x001000000010	3	0101000000001	2	x001000000010	3
027	0100101000001	2	x000001010001	2	0100101000001	2	x010000100010	4
028	0100100100000	1	x001010000101	2	0100100100000	1	x010100000101	2
029	0100010100001	2	x000000101001	2	0100010100001	2	x010000100100	3
030	0100010010000	1	x001001000000	1	0100010010000	1	x010001000000	1
031	0100001010001	2	x000000010101	2	0100001010001	2	x010000100100	4
032	0100001001000	3	x001010101000	3	0100001001000	3	x001010101000	3
033	0100001001000	4	x001010101000	4	0100001001000	4	x001010101000	4
034	0100000101001	2	x010010000001	2	0100000101001	2	x010010000001	2
035	0100000100100	3	x001010010100	3	0100000100100	3	x001010010100	3
036	0100000100100	4	x001010010100	4	0100000100100	4	x001010010100	4
037	0100000010101	2	x001010000010	3	0100000010101	2	x001010000010	3
038	0100000010010	1	x001010001010	3	0100000010010	4	x001010001010	3
039	0100000001001	2	x001010001010	4	0100000001001	2	x001010001010	4
040	0100000000100	3	x001010000010	4	0100000000100	3	x001010000010	4
041	0100000000100	4	x001001000001	2	0100000000100	4	x001001000001	2
042	x0101010000001	2	x000101000010	3	0100010101010	3	x000101000010	3
043	x0101001000000	1	x001010000101	2	0100100000010	3	x001010000101	2
044	x0100101000001	2	x000101000010	4	0100100001010	3	x000101000010	4
045	x0100100100000	1	x001000100000	1	0100100010010	3	x001000100000	1
046	x0100001010001	2	x000100100001	2	0100100100010	3	x000100100001	2
047	x0100010001000	3	x000101010100	3	0100100101010	3	x000101010100	3
048	x0100010001000	4	x000101010100	4	0100101000010	3	x000101010100	4
049	x0100000101001	2	x000010100010	3	x000010100010	3	x010000101001	2
050	x0100000100100	3	x000101001010	3	0100101001010	3	x000101001010	3
051	x0100000100100	4	x000101001010	4	0100101010010	3	x000101001010	4
052	x0100000010101	2	x000010100010	4	x000010100010	4	x010000010101	2
053	x0100000010010	3	x000101000101	2	x000001000000	1	x000101000101	2
054	x0100000010010	4	x000100010000	1	x000001000001	2	x000100010000	1
055	x0100000001001	2	x000010101010	3	x000010101010	3	x010000001001	2
056	x0100000000100	3	x000010010001	2	x000010010001	2	x010000000100	3
057	x0100000000100	4	x000001010010	3	x000001010010	3	x010000000100	4
058	x0101000000010	3	x001000000010	4	x000001000010	3	x001000000010	4
059	x0101000000010	4	x000100000001	2	x000001000010	4	x000100000001	2
060	x0101001010000	3	x001001010000	1	x000001000100	3	x001001010000	3

FIG. 17B

Data Symbol	MCG1 Code Word MSB LSB	MCG1 NCG	MCG2 Code Word MSB LSB	MCG2 NCG	DCG1 Code Word MSB LSB	DCG1 NCG	DCG2 Code Word MSB LSB	DCG2 NCG
061	x010100101000	4	x001000101000	3	x000001000100	4	x001000101000	3
062	x010101010000	1	x001000101000	4	x000001000101	2	x001000101000	4
063	0101010101000	3	x000010101010	4	0101010101000	3	x010000100101	2
064	0101010101000	4	x000010100101	2	0101010101000	4	x010000101010	3
065	0101010100000	1	x001000010100	3	0101010100000	1	x001000010100	3
066	0101010010100	3	x000010001000	3	0101010010100	3	x010000101010	4
067	0101010010100	4	x000010001000	4	0101010010100	4	x010001000100	3
068	0101010001010	3	x000001010101	2	0101010001010	3	x010001000100	4
069	0101010001010	4	x000001000100	3	0101010001010	4	x010001001000	3
070	0101010000101	2	x000001000100	4	0101010000101	2	x010001001000	4
071	0101010000010	3	x000001010010	4	0101010000010	3	x010001001001	2
072	0101010000010	4	x000001001001	2	0101010000010	4	x010001010001	2
073	0101001010000	1	x001000010100	4	0101001010000	1	x001000010100	4
074	0101001000001	2	x000000101010	3	0101001000001	2	x010001010010	3
075	0101000101000	3	x001000001010	3	0101000101000	3	x001000001010	3
076	0101000101000	4	x001000001010	4	0101000101000	4	x001000001010	4
077	0101000100000	1	x000000100010	3	0101000100000	1	x010001010010	4
078	0101000010100	3	x001000000101	2	0101000010100	3	x001000000101	2
079	0101000010100	4	x000010000000	1	0101000010100	4	x010001010101	2
080	0101000001010	3	x001010010000	1	0101000001010	3	x001010010000	1
081	0101000001010	4	x001001001000	3	0101000001010	4	x001001001000	3
082	0101000000101	2	x001001001000	4	0101000000101	2	x001001001000	4
083	0101000000010	3	x001010100001	2	0101000000010	3	x001010100001	2
084	0101000000010	4	x001001010001	2	0101000000010	4	x001001010001	2
085	0100101010100	3	x000000100010	4	0100101010100	3	x010010000000	1
086	0100101010100	4	x000000010001	2	0100101010100	4	x010010001000	3
087	0100101001010	1	x010101001000	3	0100101001010	4	x010101001000	3
088	0100101000101	2	x010101001000	4	0100101000101	2	x010101001000	4
089	0100101000010	1	x000000101010	4	0100101000010	4	x010010001000	4
090	0100100100001	2	x000000100101	2	0100100100001	2	x010010010000	1
091	0100100010000	1	x010100100100	3	0100100010000	1	x010100100100	3
092	0100100000001	2	x001000101001	2	0100100000001	2	x001000101001	2
093	0100010101010	1	x010100100100	4	0100010101010	4	x010100100100	4
094	0100010100101	2	x010100010010	3	0100010100101	2	x010100010010	3
095	0100010100010	1	x010101010001	2	0100010100010	4	x010101010001	2
096	0100010010001	2	x010100101001	2	0100010010001	2	x010100101001	2
097	0100010001000	3	x010100010010	4	0100010001000	3	x010100010010	4
098	0100010001000	4	x010100001001	2	0100010001000	4	x010100001001	2
099	0100010000000	1	x001000100100	3	0100010000000	1	x001000100100	3
100	0100001010101	2	x010010101000	3	0100001010101	2	x010010101000	3
101	0100001010010	1	x010100010101	2	0100001010010	4	x010100010101	2
102	0100001001001	2	x010100000100	3	0100001001001	2	x010100000100	3
103	0100001000100	3	x010010101000	4	0100001000100	3	x010010101000	4
104	0100001000100	4	x010010010100	3	0100001000100	4	x010010010100	3
105	0100000101010	1	x010100000100	4	0100000101010	4	x010100000100	4
106	0100000100101	2	x010010000010	3	0100000100101	2	x010010000010	3
107	0100000100010	1	x010010010100	4	0100000100010	4	x010010010100	4
108	0100000010001	2	x010010001010	3	0100000010001	2	x010010001010	3
109	0100000001000	3	x010010000010	4	0100000001000	3	x010010000010	4
110	0100000001000	4	x010001000001	2	0100000001000	4	x010001000001	2
111	x0101001000001	2	x001010101001	2	x000001001001	2	x001010101001	2
112	x0101010001010	2	x010010001010	4	x000001001010	3	x010010001010	4
113	x0101000100000	1	x010010000101	2	x000001001010	4	x010010000101	2
114	x0100101000010	3	x001010010101	2	x000001010000	1	x001010010101	2
115	x0100101000010	4	x001010000100	3	x000001010001	2	x001010000100	3
116	x0100101001010	2	x010000100000	1	x000001010010	4	x010000100000	1
117	x0100100100001	2	x001010000100	4	x000001010100	3	x001010000100	4
118	x0100100001000	3	x001010100100	3	x000001010100	4	x001010100100	3
119	x0100100001000	4	x001010100100	4	x000001010101	2	x001010100100	4
120	x0100010101010	2	x001010010010	3	x000010000000	1	x001010010010	3

FIG. 17C

Data Symbol	MCG1		MCG2		DCG1		DCG2	
	Code Word MSB LSB	NCG	Code Word MSB LSB	NCG	Code Word MSB LSB	NCG	Code Word MSB LSB	NCG
121	x010001010010	3	x001001000010	3	x000010000001	2	x001001000010	3
122	x010001010010	4	x001001000010	4	x000010000010	3	x001001000010	4
123	x010001001001	2	x001000100001	2	x000010000010	4	x001000100001	2
124	x010001000100	3	x001010010010	4	x000010000100	3	x001010010010	4
125	x010001000100	4	x001010001001	2	x000010000100	4	x001010001001	2
126	x010000010001	2	x001001010100	3	x000010000101	2	x001001010100	3
127	x010101010100	3	x001001010100	4	x000010001000	3	x001001010100	4
128	x010101010100	4	x001001001010	3	x000010001000	4	x001001001010	3
129	x010101000010	3	x000101010101	2	x000010001001	2	x000101010101	2
130	x010101000010	4	x000101000100	3	x000010001010	3	x000101000100	3
131	x010010101010	3	x001001001010	4	x000010001010	4	x001001001010	4
132	x010010101010	4	x001001000101	2	x000010010010	3	x001001000101	2
133	x010101001010	3	x001000010000	1	x000010010010	4	x001000010000	1
134	x010101001010	4	x000101010010	3	x000010010100	3	x000101010010	3
135	x010000101010	3	x000101000100	4	x000010010100	4	x000101000100	4
136	x010000101010	4	x000100100010	3	x000010010101	2	x000100100010	3
137	x010000100101	2	x000100100010	4	x000010100000	1	x000100100010	4
138	x010000100010	3	x000101010010	4	x000010100001	2	x000101010010	4
139	x010000100010	4	x000101001001	2	x000010100100	3	x000101001001	2
140	x010000001000	3	x000100010001	2	x000010100101	2	x000100010001	2
141	x010000001000	4	x000010100100	3	x000010100100	4	x010000001000	4
142	0101010101001	2	x000010100100	4	0101010101001	2	x010010010001	2
143	0101010100100	3	x000100101010	3	0101010100100	3	x000100101010	3
144	0101010100100	4	x000100101010	4	0101010100100	4	x000100101010	4
145	0101010100001	2	x001000010101	2	0101010100001	2	x001000010101	2
146	0101010010101	2	x000010010010	3	0101010010101	2	x010010100001	2
147	0101010010010	3	x000100100101	2	0101010010010	3	x000100100101	2
148	0101010010010	4	x000100001000	3	0101010010010	4	x000100001000	3
149	0101010010000	1	x001000100100	4	0101010010000	1	x001000100100	4
150	0101010001001	2	x000100001000	4	0101010001001	2	x000100001000	4
151	0101010000100	3	x000010010010	4	0101010000100	3	x010010100010	3
152	0101010000100	4	x000010001001	2	0101010000100	4	x010010100010	4
153	0101001010100	3	x000010101001	2	0101001010100	3	x010010100101	2
154	0101001010100	4	x000010010101	2	0101001010100	4	x010010101010	3
155	0101001010001	2	x001000000100	3	0101001010001	2	x001000000100	3
156	0101001001010	3	x000010000100	3	0101001001010	3	x010010101010	4
157	0101001001010	4	x000010000100	4	0101001001010	4	x010100000001	2
158	0101001001000	3	x001000010010	3	0101001001000	3	x001000010010	3
159	0101001001000	4	x001000010010	4	0101001001000	4	x001000010010	4
160	0101001000101	2	x000001000010	3	0101001000101	2	x010100000010	3
161	0101001000010	3	x000001010100	3	0101001000010	3	x010100000010	4
162	0101001000010	4	x000001010100	4	0101001000010	4	x010100001010	4
163	0101000101001	2	x001000000100	4	0101000101001	2	x001000000100	4
164	0101000100100	3	x001000001001	2	0101000100100	3	x001000001001	2
165	0101000100100	4	x000101010000	1	0101000100100	4	x000101010000	1
166	0101000100001	2	x000001001010	3	0101000100001	2	x010100010000	1
167	0101000010101	2	x000100000010	3	0101000010101	2	x000100000010	3
168	0101000010010	3	x000100101000	3	0101000010010	3	x000100101000	3
169	0101000010010	4	x000100101000	4	0101000010010	4	x000100101000	4
170	0101000010000	1	x000001000010	4	0101000010000	1	x010100010100	3
171	0101000001001	2	x000100010100	3	0101000001001	2	x000100010100	3
172	0101000000100	3	x000100000010	4	0101000000100	3	x000100000010	4
173	0101000000100	4	x000010000001	2	0101000000100	4	x010100010100	4
174	0100101010101	2	x000001001010	4	0100101010101	2	x010100100000	1
175	0100101010010	1	x000000100001	2	0100101010010	4	x010100100001	2
176	0100101010000	1	x000100010100	4	0100101010000	1	x000100010100	4
177	0100101001001	2	x010101010101	2	0100101001001	2	x010100101000	3
178	0100101000100	3	x000001000101	2	0100101000100	3	x010100101000	4
179	0100101000100	4	x000000010000	1	0100101000100	4	x010100101010	3
180	0100100101010	1	x010100100010	3	0100100101010	4	x010100100010	3

FIG. 17D

Data Symbol	MCG1		MCG2		DCG1		DCG2	
	Code Word MSB LSB	NCG	Code Word MSB LSB	NCG	Code Word MSB LSB	NCG	Code Word MSB LSB	NCG
181	0100100101000	3	x000100001010	3	0100100101000	3	x000100001010	3
182	0100100101000	4	x000100001010	4	0100100101000	4	x000100001010	4
183	0100100100101	2	x010100100010	4	0100100100101	2	x010100100010	4
184	0100100100010	1	x010101010010	3	0100100100010	4	x010101010010	3
185	0100100010100	3	x000100000101	2	0100100010100	3	x000100000101	2
186	0100100010100	4	x000001000000	1	0100100010100	4	x010100101010	4
187	0100100010001	2	x010101010010	4	0100100010001	2	x010101010010	4
188	0100100000101	1	x010101001001	2	0100100001010	4	x010101001001	2
189	0100100001000	3	x010100010001	2	0100100001000	3	x010100010001	2
190	0100100001000	4	x010010100100	3	0100100001000	4	x010010100100	3
191	0100100000101	2	x010100100101	2	0100100000101	2	x010100100101	2
192	0100100000010	1	x010010100100	4	0100100000010	4	x010010100100	4
193	0100010101001	2	x010010010010	3	0100010101001	2	x010010010010	3
194	0100010100100	3	x010100001000	3	0100010100100	3	x010100001000	3
195	0100010100100	4	x010100001000	4	0100010100100	4	x010100001000	4
196	0100010010101	2	x010010010010	4	0100010010101	2	x010010010010	4
197	0100010010010	1	x010010101001	2	0100010010010	4	x010010101001	2
198	0100010001001	2	x010010010101	2	0100010001001	2	x010010010101	2
199	0100010000100	3	x010010001001	2	0100010000100	3	x010010001001	2
200	0100010000100	4	x010001010100	3	0100010000100	4	x010001010100	3
201	0100010000001	2	x010001010100	4	0100010000001	2	x010001010100	4
202	0100001010100	3	x010010000100	3	0100001010100	3	x010010000100	3
203	0100001010100	4	x010010000100	4	0100001010100	4	x010010000100	4
204	0100001001010	1	x010001000010	3	0100001001010	4	x010001000010	3
205	0100001000101	2	x010001000010	4	0100001000101	2	x010001000010	4
206	0100001000010	1	x010001001010	3	0100001000010	4	x010001001010	3
207	0100001000000	1	x010000100001	2	0100001000000	1	x010000100001	2
208	0100000100001	2	x010001001010	4	0100000100001	2	x010001001010	4
209	0100000010000	1	x001010101010	3	0100000010000	1	x001010101010	3
210	x010101000100	3	x001010101010	4	x000010101000	3	x001010101010	4
211	x010101000100	4	x001010100101	2	x000010101000	4	x001010100101	2
212	x010100101010	3	x010001000101	2	x000010101001	2	x010001000101	2
213	x010100101010	4	x010000010000	1	x000010101010	4	x010000010000	1
214	0101010101010	3	x001010001000	3	0101010101010	3	x001010001000	3
215	0101010101010	4	x001010001000	4	0101010101010	4	x001010001000	4
216	0101010100101	2	x001001010101	2	0101010100101	2	x001001010101	2
217	0101010100010	3	x001010100010	3	0101010100010	3	x001010100010	3
218	0101010100010	4	x001010100010	4	0101010100010	4	x001010100010	4
219	0101010010001	2	x001010010001	2	0101010010001	2	x001010010001	2
220	0101010001000	3	x001001000100	3	0101010001000	3	x001001000100	3
221	0101010001000	4	x001001000100	4	0101010001000	4	x001001000100	4
222	0101001010101	2	x001000100010	3	0101001010101	2	x001000100010	3
223	0101001010010	3	x001001010010	3	0101001010010	3	x001001010010	3
224	0101001010010	4	x001001010010	4	0101001010010	4	x001001010010	4
225	0101001001001	2	x001001001001	2	0101001001001	2	x001001001001	2
226	0101001000100	3	x001000100010	4	0101001000100	3	x001000100010	4
227	0101001000100	4	x001000010001	2	0101001000100	4	x001000010001	2
228	0101000101010	3	x001000101010	3	0101000101010	3	x001000101010	3
229	0101000101010	4	x001000101010	4	0101000101010	4	x001000101010	4
230	0101000100101	2	x001000100101	2	0101000100101	2	x001000100101	2
231	0101000100010	3	x000101001000	3	0101000100010	3	x000101001000	3
232	0101000100010	4	x000101001000	4	0101000100010	4	x000101001000	4
233	0101000010001	2	x000100100100	3	0101000010001	2	x000100100100	3
234	0101000001000	3	x001000001000	3	0101000001000	3	x001000001000	3
235	0101000001000	4	x001000001000	4	0101000001000	4	x001000001000	4
236	0100101010001	2	x000101010001	2	0100101010001	2	x000101010001	2
237	0100101001000	3	x000100100100	4	0100101001000	3	x000100100100	4
238	0100101001000	4	x000100010010	3	0100101001000	4	x000100010010	3
239	0100100101001	2	x000100101001	2	0100100101001	2	x000100101001	2
240	0100100100100	3	x000100010010	4	0100100100100	3	x000100010010	4

FIG. 17E

Data Symbol	NCG1		NCG2		DCG1		DCG2	
	Code Word MSB LSB	NCG	Code Word MSB LSB	NCG	Code Word MSB LSB	NCG	Code Word MSB LSB	NCG
241	0100100100100	4	x000100001001	2	0100100100100	4	x000100001001	2
242	0100100010101	2	x000100010101	2	0100100010101	2	x000100010101	2
243	0100100010010	1	x000010101000	3	0100100010010	4	x010101000001	2
244	0100100001001	2	x000010101000	4	0100100001001	2	x010101000010	3
245	0100100000100	3	x000100000100	3	0100100000100	3	x000100000100	3
246	0100100000100	4	x000100000100	4	0100100000100	4	x000100000100	4
247	0100010101000	3	x000010010100	3	0100010101000	3	x010101000010	4
248	0100010101000	4	x000010010100	4	0100010101000	4	x010101000100	3
249	0100010010100	3	x000010001010	3	0100010010100	3	x010101000100	4
250	0100010010100	4	x000010001010	4	0100010010100	4	x010101000101	2
251	0100010001010	1	x000010000101	2	0100010001010	4	x010101001010	3
252	0100010000101	2	x000000100000	1	0100010000101	2	x010101001010	4
253	0100010000010	1	x000010000010	3	0100010000010	4	x010101010000	1
254	0100001000001	2	x000010000010	4	0100001000001	2	x010101010100	3
255	0100000100000	1	x000001000001	2	0100000100000	1	x010101010100	4

FIG. 18

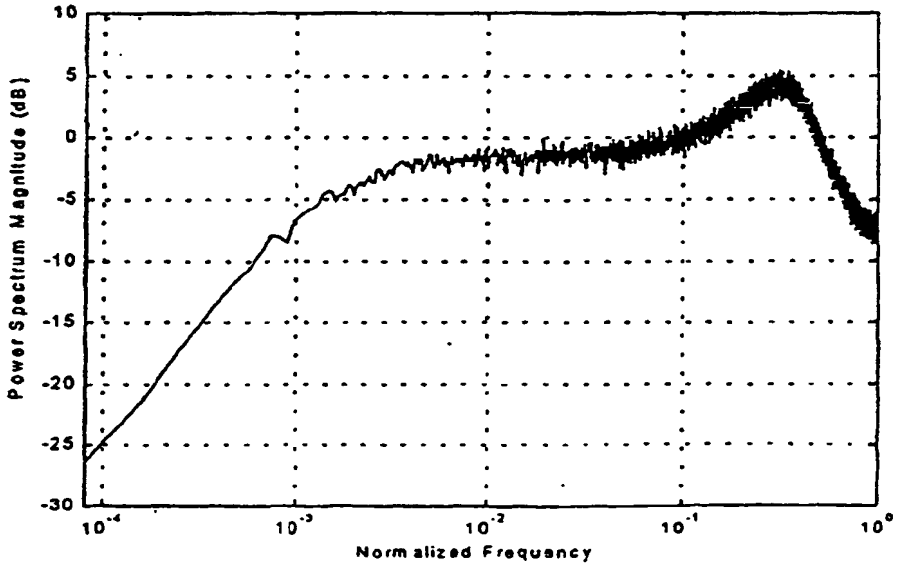


FIG. 19

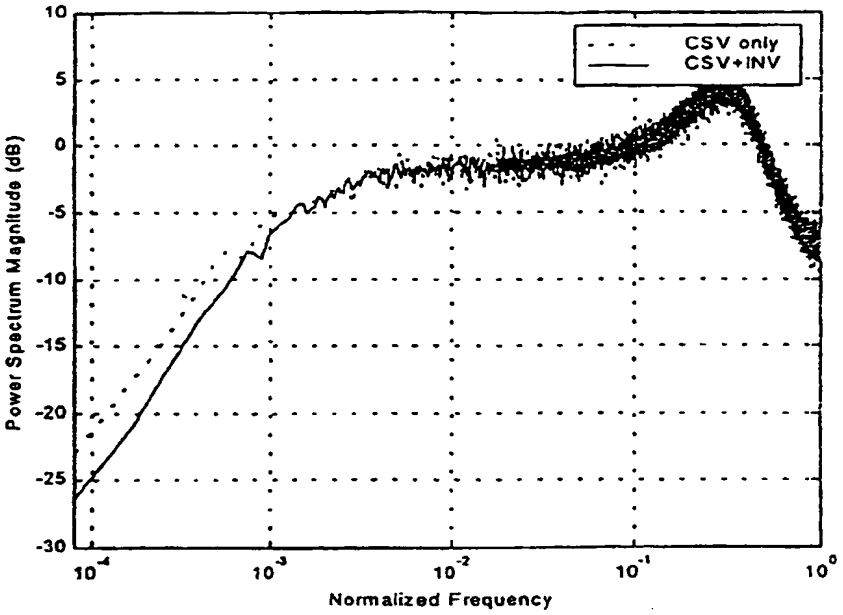


FIG. 20

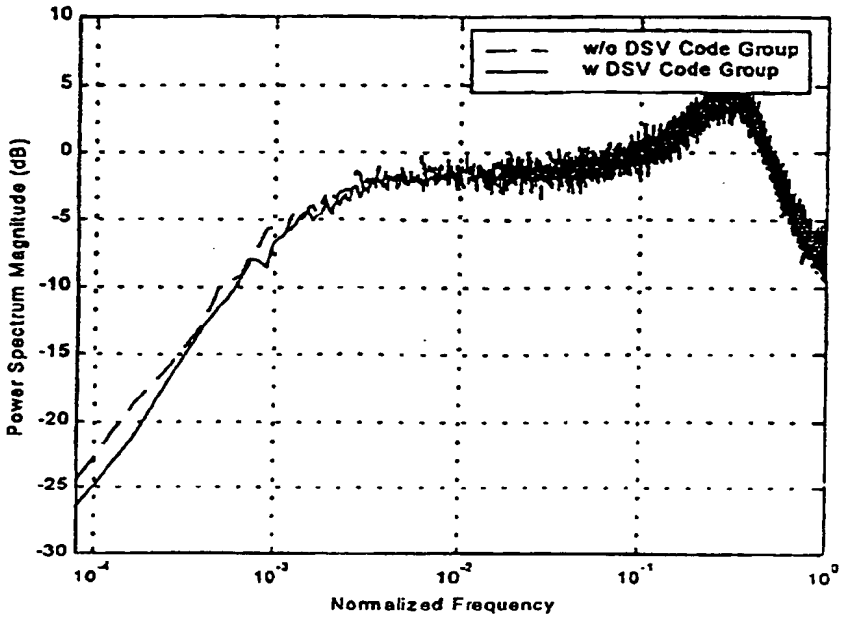


FIG. 21

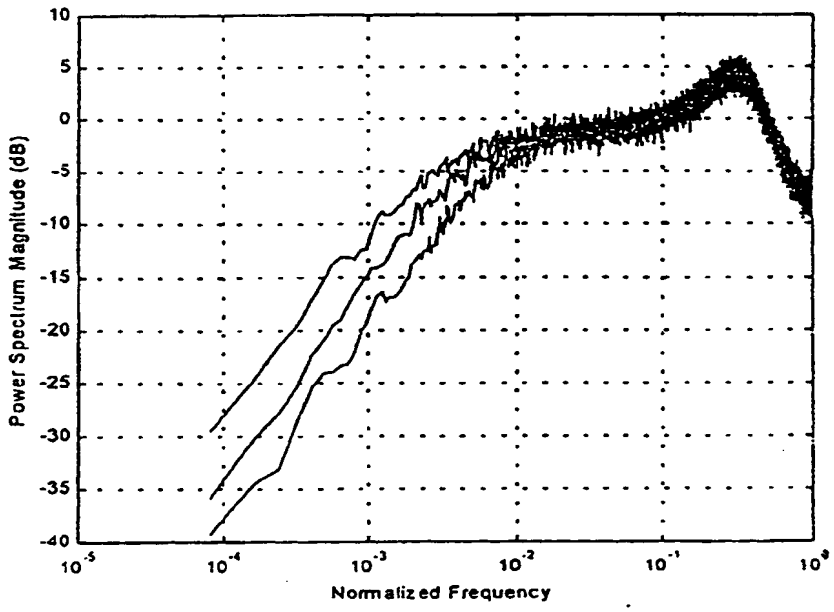
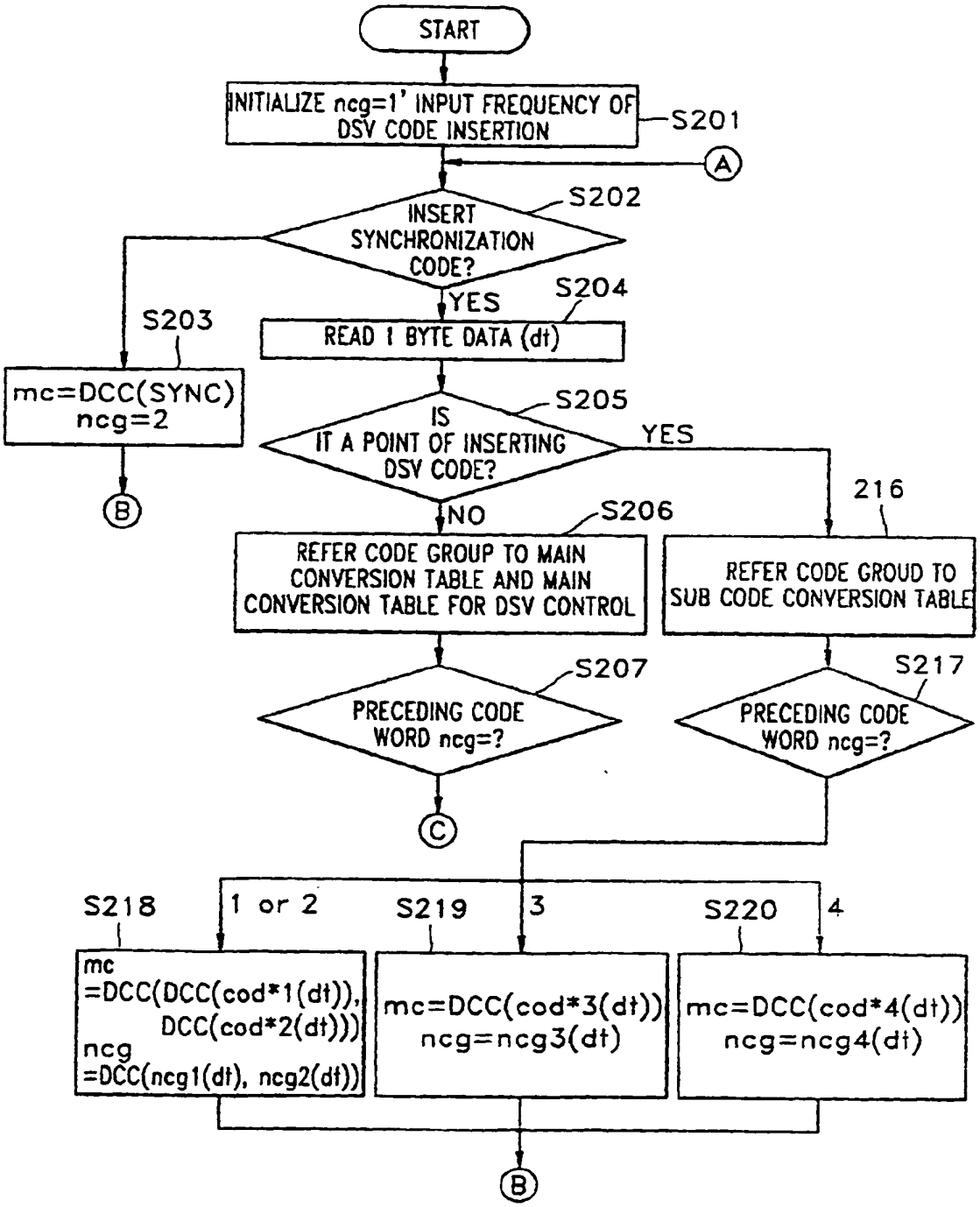


FIG. 22A



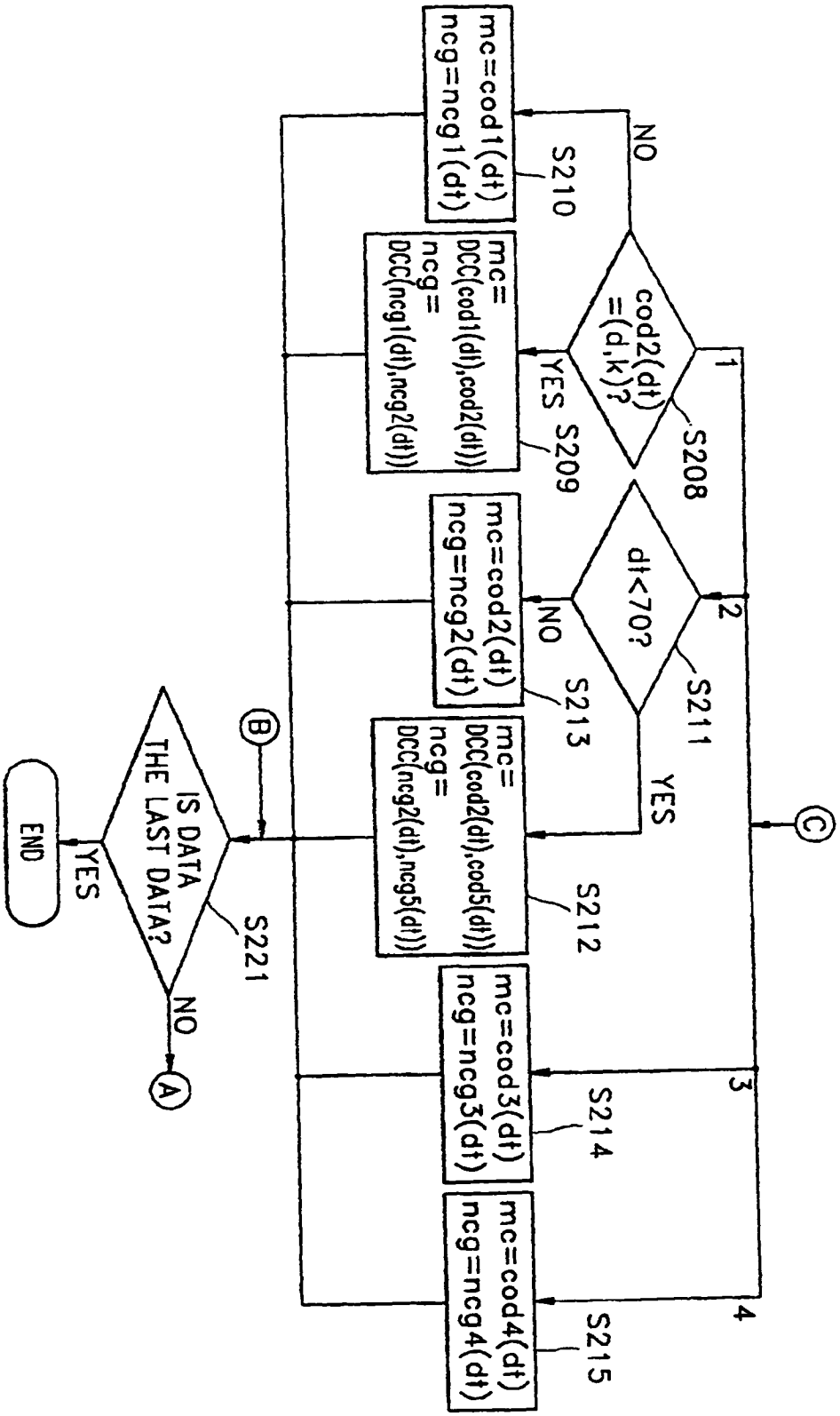


FIG. 22B

FIG. 23

CODE GROUP POINTED OUT BY NCG	SYNC TYPE	MSB LSB	MSB LSB
MCG1 OR DCG2	SYNC0	010100000010 000000001001	100001010010 000000001001
	SYNC1	100100000010 000000001001	100101000010 000000001001
	SYNC2	010010000010 000000001001	010101000010 000000001001
	SYNC3	010000010010 000000001001	010100010010 000000001001
	SYNC4	100001000010 000000001001	100100010010 000000001001
	SYNC5	100101010010 000000001001	010010010010 000000001001
	SYNC6	010001000010 000000001001	010001010010 000000001001
MCG2 OR DCG1	SYNC0	000010100010 000000001001	001000000010 000000001001
	SYNC1	000100100010 000000001001	010010100010 000000001001
	SYNC2	001010000010 000000001001	001010100010 000000001001
	SYNC3	001000010010 000000001001	000000100010 000000001001
	SYNC4	001000100010 000000001001	001001010010 000000001001
	SYNC5	010000100010 000000001001	001010010010 000000001001
	SYNC6	001001000010 000000001001	010100100010 000000001001

FIG. 24

CODE GROUP POINTED OUT BY NCG	SYNC TYPE	MSB LSB	MSB LSB
MCG1 OR DCG1	SYNC0	100000100010 000000001001	101000010010 000000001001
	SYNC1	100001000010 000000001001	101000100010 000000001001
	SYNC2	100101010010 000000001001	100100010010 000000001001
	SYNC3	100010000010 000000001001	100010010010 000000001001
	SYNC4	101001010010 000000001001	100100100010 000000001001
	SYNC5	101010100010 000000001001	101001000010 000000001001
	SYNC6	100100000010 000000001001	100001010010 000000001001
	SYNC7	101010010010 000000001001	100101000010 000000001001
MCG2 OR DCG2	SYNC0	010000100010 000000001001	010100010010 000000001001
	SYNC1	001000010010 000000001001	001010010010 000000001001
	SYNC2	010001000010 000000001001	010010010010 000000001001
	SYNC3	001000100010 000000001001	001010100010 000000001001
	SYNC4	010101010010 000000001001	010001010010 000000001001
	SYNC5	001001000010 000000001001	010010100010 000000001001
	SYNC6	010010000010 000000001001	010100100010 000000001001
	SYNC7	000100010010 000000001001	010101000010 000000001001

FIG. 25

ncg	WHEN IT IS NOT AT A POINT OF INSERTING CODE WORD FOR DSV CONTROL	WHEN IT IS AT A POINT OF INSERTING CODE WORD FOR DSV CONTROL
	USE MAIN CONVERSION TABLE AND MAIN CONVERSION TABLE FOR DSV CONTROL	USE ONLY MAIN CONVERSION TABLE FOR DSV CONTROL
1	MCG1 OR MCG2	MCG1 OR MCG2
2	MCG2 OR DSV CODE GROUP	
3	DCG1	DCG1
4	DCG2	DCG2

FIG. 26A

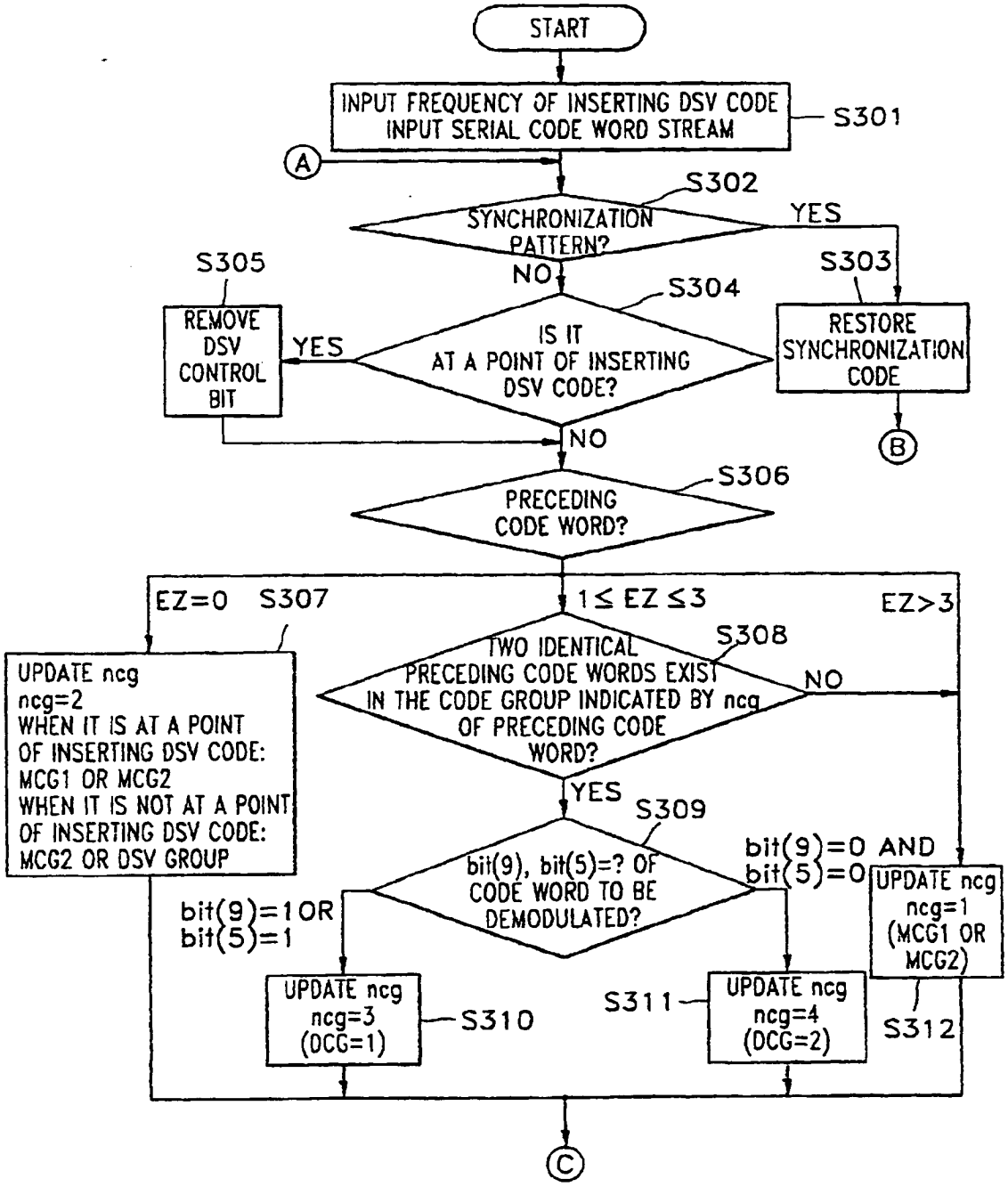


FIG. 26B

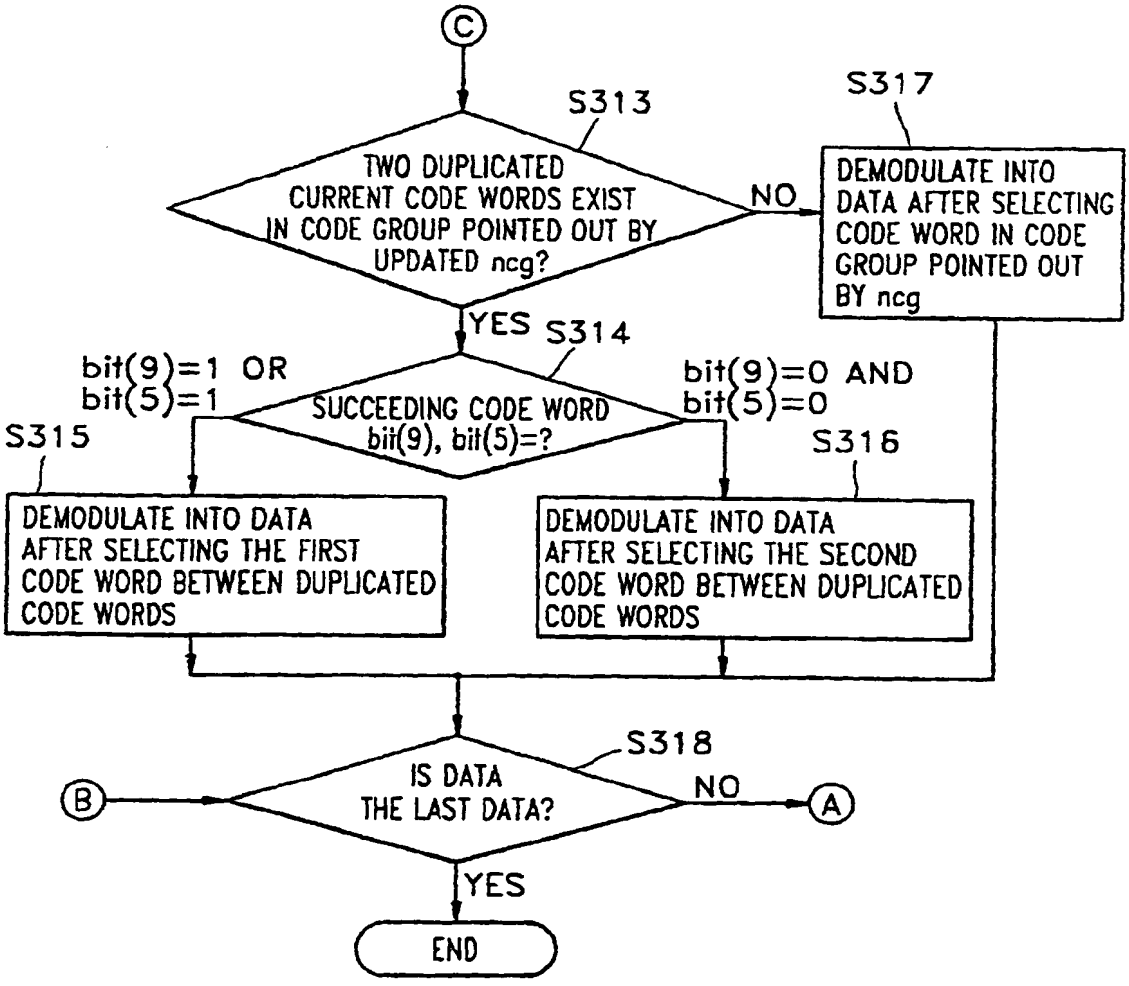


FIG. 27

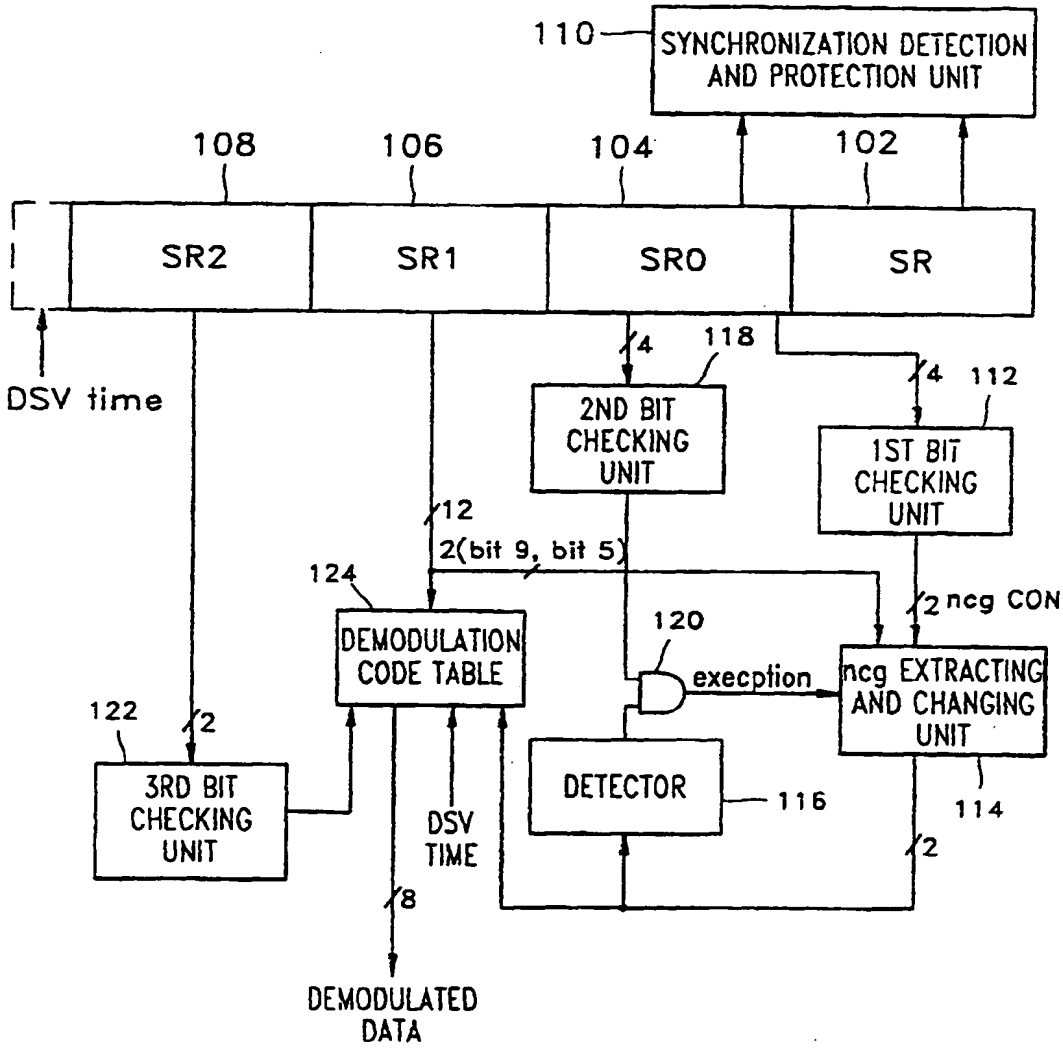


FIG. 28A

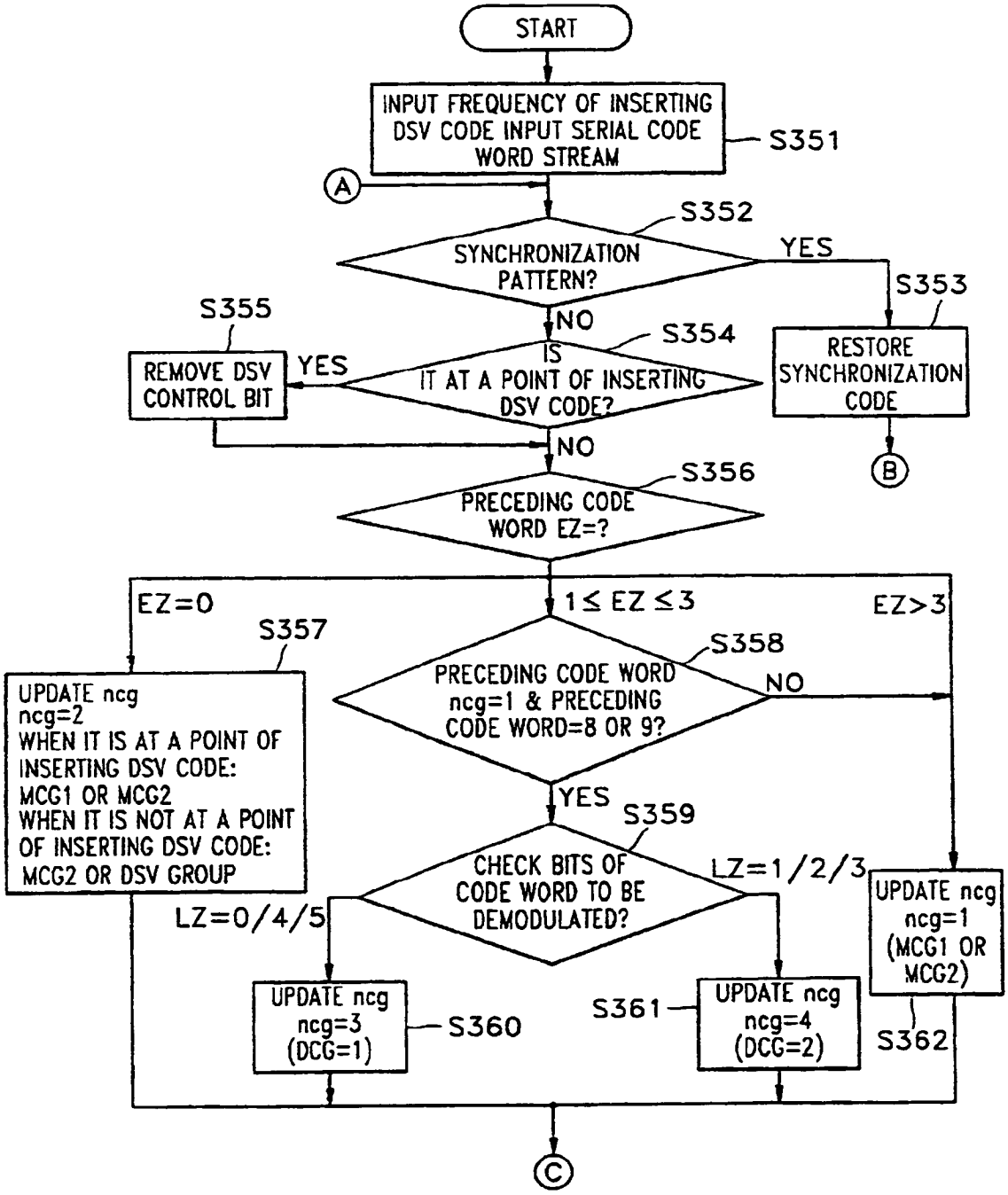


FIG. 28B

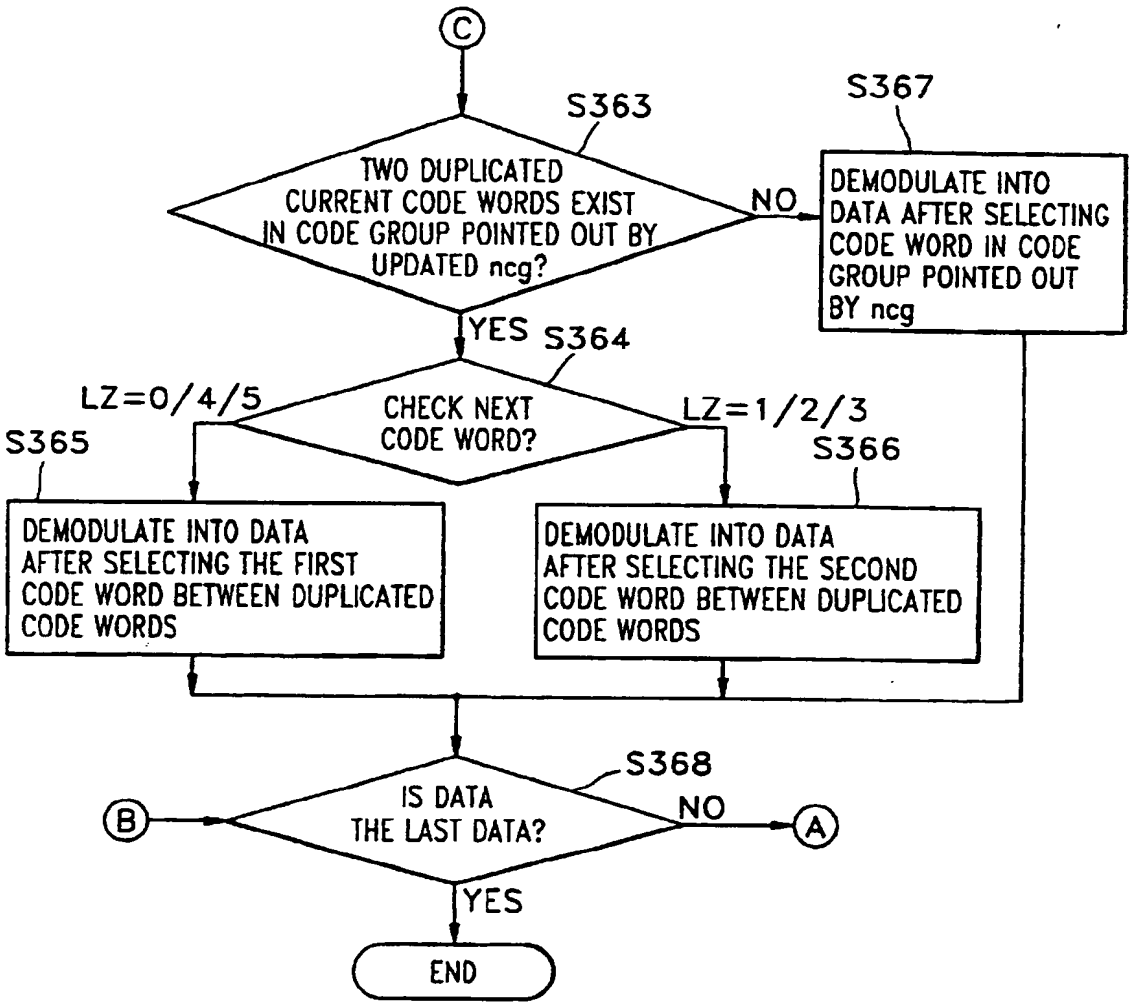
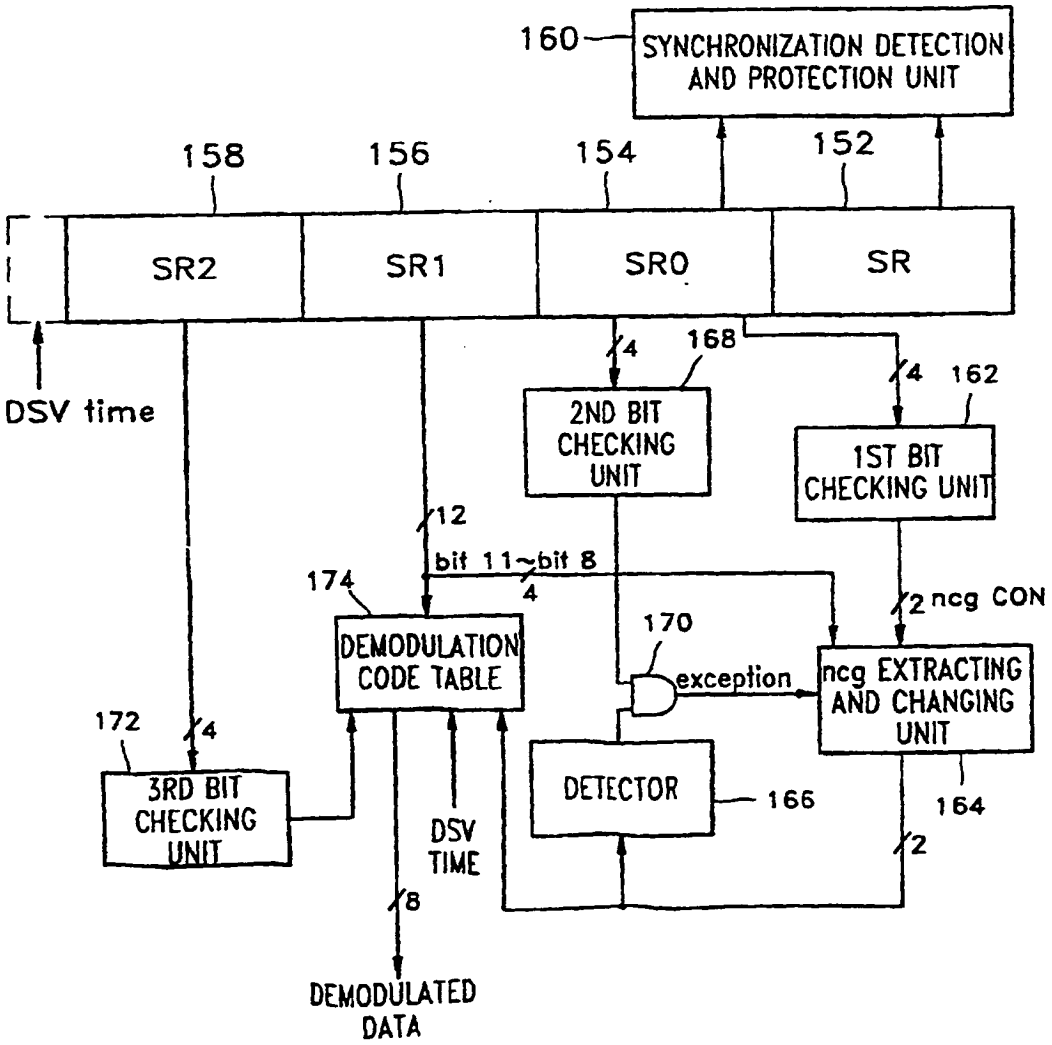


FIG. 29



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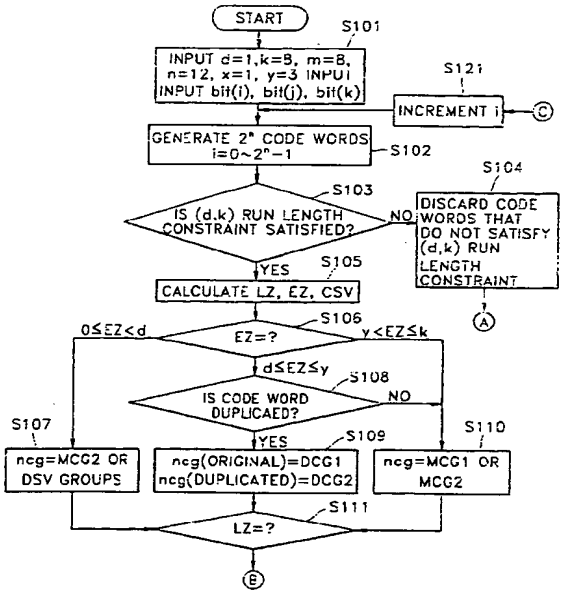
(54) RLL modulation with enhanced DC suppression

(57) An allocating method of allocating a run length limited (RLL) code having enhanced direct current (DC) suppression capability, modulation and demodulation methods, and a demodulation apparatus are provided. In order to control DC suppression, a pair of code groups having suppression controlling capability are allocated, and a (1, 8, 8, 12) code having DC suppression capability, in which

a code word of the pair of code groups has the sign of code word sum value (CSV) parameter, which represent DC value in a code word, and the characteristic of an INV parameter, which predicts the transition direction of digital sum value (DSV) of the succeeding code word, both opposite to those of the code word which belongs to the other code group and corresponds to the same source code, is used and is appropriate to high-density optical disc system.

FIG. 5A



EP 1 047 197 A3

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EUROPEAN SEARCH REPORT

Application Number
EP 00 30 3324

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	US 5 790 056 A (SCHOUHAMER IMMINK KORNELIS A) 4 August 1998 (1998-08-04) * column 1, line 11 - line 15 * * column 4, line 6 - line 37 * * column 5, line 30 - line 36 *	1-5, 13-29, 38-47	H03M5/14 G11B20/14
X	EP 0 771 078 A (HEWLETT PACKARD CO) 2 May 1997 (1997-05-02)	5	
A	* abstract * * page 3, line 28 - line 35 * * page 3 * * page 4, line 50 - line 55 * * page 5, line 4 - line 6 * * page 6, line 42 - line 53 * * page 11, line 5 - line 9 *	1-4, 13-29, 38-47	
E	EP 1 037 389 A (SAMSUNG ELECTRONICS CO LTD) 20 September 2000 (2000-09-20) * the whole document *	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.7)
H03M
G11B

~~The present search report has been drawn up for all claims~~

Place of search	Date of completion of the search	Examiner
Munich	23 December 2004	Winkler, G

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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
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EPO FORM 1503 03.82 (P04C01)

European Patent Office

Application Number
EP 00 30 3324

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing more than ten claims.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

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☒ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

see annex

SDOCID: <EP_____1047197A3_I_>

European Patent Office

LACK OF UNITY OF INVENTION
SHEET B

Application Number
EP 00 30 3324

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-4,5,13-29,38-47

The special technical feature which distinguish the claims of this invention over the prior art (cf Section "Prior Art" below) are the features of the independent claims 1, 13 and 38, which define that the code words of the code groups corresponding to the same source code have opposite signs of the code word sum value and opposite characteristic of the parameter which predicts the transition direction of the digital sum value.
This feature solves the problem of providing means that enable a selection of a code word which reduces the DC-content in the data stream during RLL-coding.

---

2. claims: 6-12,13-29,38-47,49-63

The special technical feature which distinguish the claims of this invention over the prior art (cf "Prior Art" below) are the features of the independent claims 6, 13, 38 and 49, which define that a decision code group includes a code word following a duplicated code word and that a main code group which includes a code word following a not duplicated code word.
This feature solves the problem of providing enough code words by reusing code words.

---

3. claims: 13-29,30-37,38-47,48

The special technical feature which distinguish the claims of his invention over the prior art (cf section "Prior Art" below) are the features of the independent claims 13, 30, 38 and 48 which define that at a point of DSV control m-bit input data are modulated with inserting a codeword for DSV control.
This feature solves the problem of enhancing the DC-suppression already provided by the RLL-coding by adding a dedicated digital sum value control point.

SDOCID: <EP_____1047197A3_I_>

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 00 30 3324

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23-12-2004

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5790056 A	04-08-1998	AT 201527 T	15-06-2001
		AU 703791 B2	01-04-1999
		AU 6666796 A	27-03-1997
		CA 2205565 A1	13-03-1997
		CN 1516175 A	28-07-2004
		CN 1166225 A ,C	26-11-1997
		DE 69612955 D1	28-06-2001
		DE 69612955 T2	20-12-2001
		EP 0789910 A1	20-08-1997
		ES 2159040 T3	16-09-2001
		GR 3036397 T3	30-11-2001
		HK 1004699 A1	17-12-2004
		HU 9801354 A2	28-10-1998
		WO 9709718 A1	13-03-1997
		ID 16164 A	11-09-1997
		IL 120740 A	26-07-2000
		JP 10508456 T	18-08-1998
		PL 320006 A1	01-09-1997
		PT 789910 T	30-11-2001
		RU 2153200 C2	20-07-2000
		TW 394931 B	21-06-2000
		ZA 9607261 A	27-02-1998
EP 0771078 A	02-05-1997	US 6002718 A	14-12-1999
		DE 69611150 D1	11-01-2001
		DE 69611150 T2	05-04-2001
		EP 0771078 A2	02-05-1997
		JP 9223969 A	26-08-1997
EP 1037389 A	20-09-2000	KR 2000059841 A	05-10-2000
		CN 1267057 A	20-09-2000
		EP 1037389 A2	20-09-2000
		JP 3466130 B2	10-11-2003
		JP 2000286710 A	13-10-2000
		US 6268810 B1	31-07-2001

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